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WATER SUPPLY FROM COAST TO COAST

❖

EIGHT
TIMELY
ARTICLES

❖

HARTFORD

Undertakes Third Enlargement in 83 Years

CHICAGO

Plans Filters and Meters for South Side

MICHIGAN CITY

Improves Works Under New Indiana Law

SALT LAKE CITY

Develops Well Supply to Meet Surface Shortage

CINCINNATI

Simplifies Consumer Accounting by Stub Plan

DENVER

Crosses the Continental Divide for New Supply

ABERDEEN, S. D.

Abandons Wells for a Treated Surface Supply

LOS ANGELES

Increases Plant Capacity by Improving Clarifier

☆
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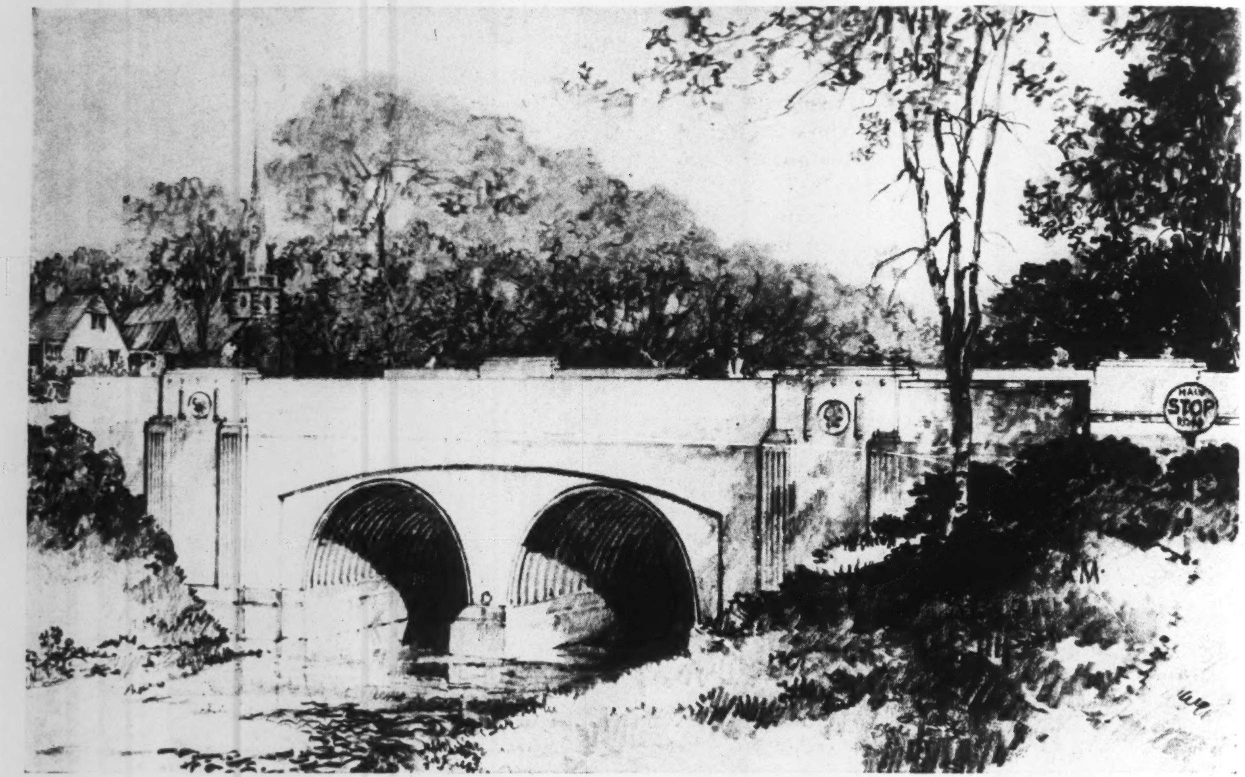

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A MOMENT WITH THE PUBLISHERS

What About *"Bigness"*?

WE hear a lot about "bigness." Government, we are told, must use its taxing power and other resources to curb "business bigness," to penalize expansion and set limits to the growth of any enterprise.

Although we may understand the motives of those who advocate such a policy and although the record of business expansion may reveal evils sufficient to justify them, it is in order to ask whether bigness, as such, really is the cause of those evils or simply an independent condition that may be a contributing factor.

Certainly a strong case might be made against bigness in some fields on grounds quite apart from those of general social or economic welfare. The theory of "big business" is that large resources make for large volume, lower costs and higher overall efficiency. But many industrialists have been wondering if this theory has not been driven to excess. They know that bigness has its penalties as well as its rewards and that the law of diminishing returns may set a point where the penalties of the next stage in growth will outweigh the returns.

FOR example: as a business expands, its capital and other fixed charges are likely to increase; a substantial loss of volume may find it unable to cut its costs proportionally. Bigness often tends to breed "absentee management" which does not make for productive industrial efficiency; the top management tends to lose touch with practical realities; inflexibility and faulty coordination breed waste. Bureaucracy tends to supersede keen personal management; key men become more concerned over playing politics for their own advancement or protection than over the progress of the business. Initiative wanes; the dominant instincts of the organization become "safety first" and "pass the buck." These facts are recognized by wise industrialists; as a result we have seen during recent years a trend toward decentralization of operating control even in large concerns.

Of course it may be argued that such deficiencies carry their own correctives, that the business that fosters them must yield to more aggressive and efficient competitors, whether larger or smaller. To effect just this, we are told, is the function of our competitive system.

All of which would be an adequate answer if the system worked out that way; but right there lies the real issue of bigness. For it is not bigness itself or its effects on the big enterprise that constitute the evils now under attack; rather is it the *power* that resides in bigness and the *use* that is made of it. When that power is used fairly, under the rules of our competitive economy, it needs no artificial curb. But when it is used to thwart those rules and to evade the natural penalties of inefficiency it breeds evil in the economic community.

When, under free competition, the power of bigness is applied to improve a product or service, to make it more widely available, to reduce its price and thereby broaden its use, to increase the earnings of bona fide investors and to foster technical progress within its field, it becomes a constructive contribution to the general welfare.

But when it is used to effect monopoly and maintain excessive prices, to destroy competition by predatory trade practices or to forestall it by illicitly closing a market to new and more aggressive enterprise, to retard technical progress in order to protect vested interest, to debauch public servants and to pervert governmental influence to private advantage, or to set up financial structures designed to create fictitious values, deceive bona fide investors and cover up inside manipulation—then bigness becomes a blight on the national economy and undermines the very competitive system that has nurtured it.

BEARING in mind all this and other considerations, it must be evident that "bigness" itself is not the issue. True, these evils have been associated with bigness, but some Big Business has amply demonstrated its will and capacity to serve the American people progressively, efficiently and honestly. Our task is to attack these evils wherever they may be found, not to strike from the hands of creative industry one of its most useful instruments just because it has been misused by some in an effort to avert the natural economic penalties of their own shortcomings.

Willard Chevalier

ENGINEERING NEWS-RECORD

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In the News:

GRADE-CROSSINGS do not have to qualify under the $1,400 per man-year direct-labor provision, but states may not submit an alternate plan for using work-relief grade-crossing funds, in accordance with recent rule-change approvals by the President, which revoke Sections 6 and 22 of the Relief and Construction Act of 1935.

FLOOD NEWS, which has come from a different part of the country nearly every week, originates in Richmond, Va., this time. Heavy rains caused $1,000,000 damage throughout the state, and the James River flooded out the Richmond gas plant.

THE FIRST of the twenty-six Mississippi River navigation dams, planned to provide a 9-ft. channel from St. Louis to the Twin Cities, was dedicated last week at Alma, Wis. It includes a steel roller-gate dam and concrete ship locks.

THE ARMY ENGINEERS are to be in charge of river and harbor work as a permanent national policy by virtue of the wording of the Rivers & Harbors Act of 1935. Heretofore, for upwards of a hundred years, the corps has annually been only a temporary appointee to the task by Congress.

DAMS IN NEW MEXICO are in the week's news. Condemnation proceedings have been instituted to secure title to 38,000 acres of land in connection with the Conches Dam on the Canadian River north of Tucumcari, while further south construction of a dam on the Rio Grande at Caballo, 20 miles below Elephant Butte, is said to be assured by the transfer of $1,500,000 from the Rio Grande rectification funds to the Bureau of Reclamation.

In This Issue:

Coincident with the 54th annual convention of the New England Water Works Association, this issue brings to waterworks engineers and public officials generally a group of articles that both picture the present state of the art from coast to coast and expressly portray a large number of specific problems and their solutions.

HARTFORD IS carrying on, without federal aid, the third extension of its supply sources in 83 years. The principal present construction item is the Bills Brook earth dam, creating the new Barkhamsted Reservoir.

DENVER, TOO, requires new sources and is going across the Continental Divide to secure them, first in the Fraser River and its tributaries. The pioneer bore of the Moffet railroad tunnel will bring the water through the Divide to the East Slope country.

Stress Analysis Dissected

PROFESSOR HARDY CROSS, one of our leading exponents of structural science, has written an intensely interesting critical study of what the engineer does when he computes stresses. The author's exploratory searchlight is directed mainly to the complex methods devised for analyzing statically indeterminate structures. His main conclusions are two: that simple methods are best, and that the engineer ought to know what his computed stresses really mean. The article will be published soon.

SALT LAKE CITY'S surface supplies proved inadequate during the drought, forcing the purchase of artesian wells and the beginning of an intensive program of new well development in the Jordan Valley.

ABERDEEN, S. D., on the other hand, after depending for half a century on deep wells, has been forced to develop a new impounded surface supply. The reservoir is 20 miles from town, the treatment plant 7 miles.

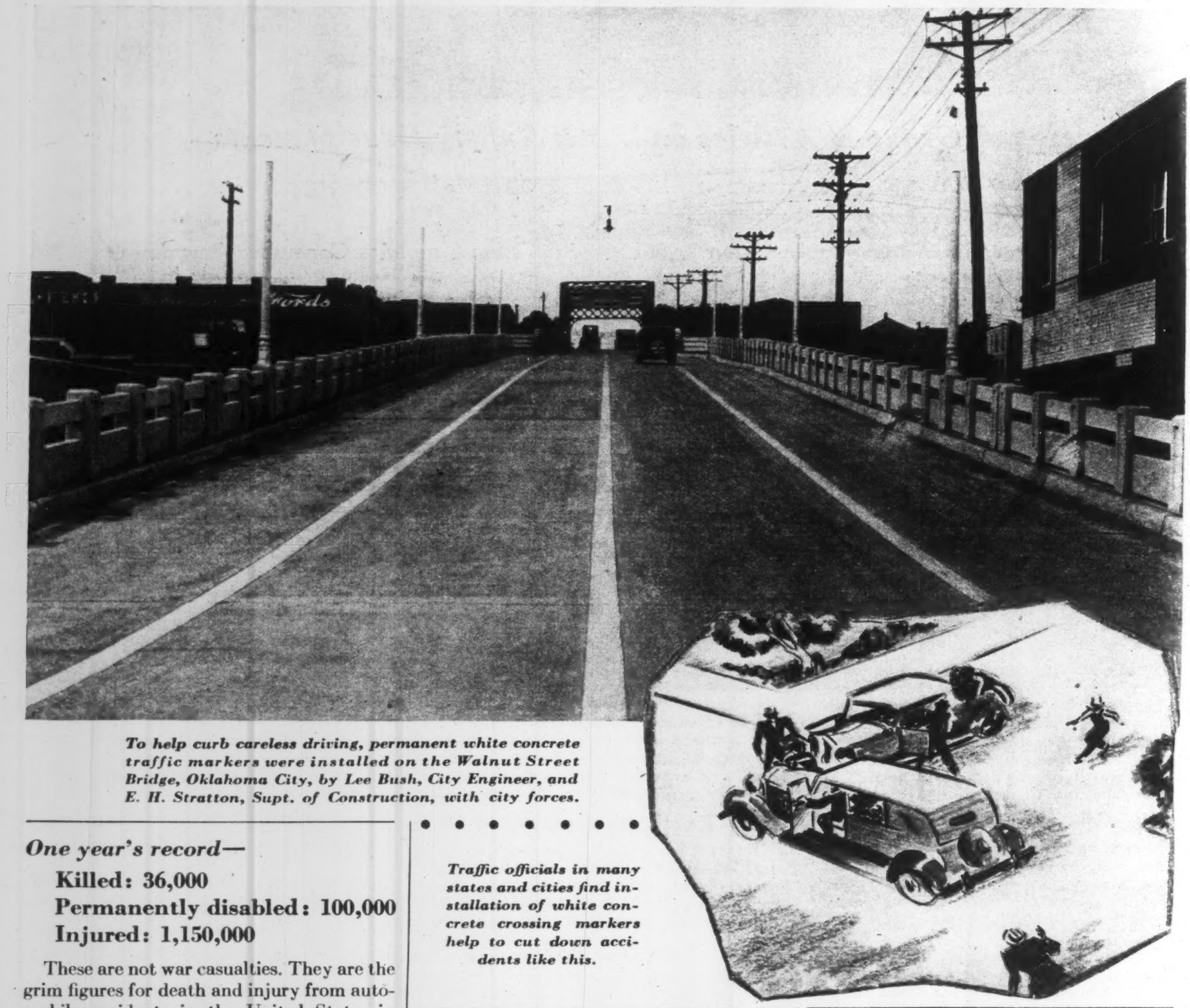
MICHIGAN CITY, IND., by placing its waterworks on a modern business footing, in which it was aided by a new state law, has been enabled to provide filtration, new pumps and additional storage.

CINCINNATI, TOO, is improving its business methods, saving one-half former costs of meter-reading, bill preparation, delinquent procedure and office accounting largely by inauguration of a three-part bill, which includes a cashier's stub, delinquent notice and an office record.

LOS ANGELES increased the capacity of its Wilmington filter plant by reducing flow turbulence and floc breakage in the clarifier unit, merely by revamping the inlet and lengthening the effluent weir.

CHICAGO is again taking up its plan for filtering Lake Michigan water. It has designs for complete filtration and metering in its South District, which it has submitted to PWA for a loan and grant of $21,000,000.

WHITE CONCRETE TRAFFIC MARKERS AID IN DRIVE FOR TRAFFIC SAFETY



To help curb careless driving, permanent white concrete traffic markers were installed on the Walnut Street Bridge, Oklahoma City, by Lee Bush, City Engineer, and E. H. Stratton, Supt. of Construction, with city forces.

● ● ● ● ● ● ●

Traffic officials in many states and cities find installation of white concrete crossing markers help to cut down accidents like this.

One year's record—

Killed: 36,000
Permanently disabled: 100,000
Injured: 1,150,000

These are not war casualties. They are the grim figures for death and injury from automobile accidents in the United States in 1934. And up to August 1 this year motor cars have killed another 18,000 and have injured 35 times that many men, women and children in this country.

What can be done? Three things, says the National Safety Council: 1. Educate drivers and pedestrians to safety. 2. Keep vehicles in good condition. 3. Improve our streets and highways safety-wise.

In every part of the country, highway and traffic officials, as well as members of the automotive industry, are making a concerted drive to carry out this 3-point safety program—determined to batter down the steadily rising curve of death and injury.

No one means, of course, can be singled out as a cure-all. But in the drive to build greater safety into streets and highways (point 3 in the program) there is one thing which officials have found helpful—permanent white concrete traffic markers.

These white concrete markers, made with *white* portland cement, combine *constant* visibility (and hence greater safety) with economy. They are not surface markers, but are built *into* the pavement—asphalt, brick or concrete. They can't be worn away. They never fade out. They never need replacement. They are *always* white—*always* easy to see. Write for complete information to Universal Atlas Cement Co. (United States Steel Corporation Subsidiary), 208 South La Salle Street, Chicago.

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Help Build Safety into Streets and Highways with

ATLAS WHITE TRAFFIC MARKERS

Made with Atlas White Portland Cement—Plain and Waterproofed

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September 12, 1935

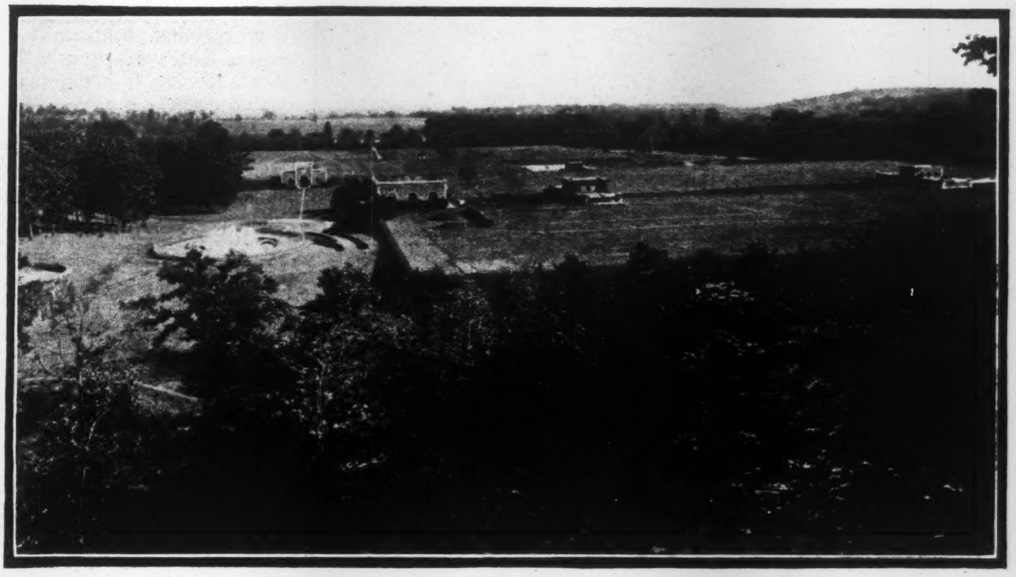


FIG. 1—FILTRATION PLANT and administration building of Hartford Metropolitan Water Bureau.

Third Enlargement in 83 Years Under Way in Hartford

By Caleb Mills Saville

Manager and Chief Engineer, Water Bureau of Metropolitan District, Hartford, Conn.

SINCE the vote at the city meeting, July, 1852, and the actual work that was begun two years later with a simple pumping engine forcing water through a single pipe line to a small reservoir on a near-by hillside for the supply of some 1,300 service connections, the water authority of Hartford, Conn., has always endeavored to keep pace with the needs of an expanding community devoted largely to industrial specialties and the insurance business. In 1859 the 2,000 people of this community used 661,000 gal. and paid 9c. per 1,000 gal. for it. As of Dec. 31, 1934, the draft was 18.5 m.g.d. by the 213,000 people supplied through 27,000 services at 14.5c. per 1,000 gal. The small increase in rates made during the past three-fourths of a century, compared with the tremendous rise of labor and material costs in this same period, bespeaks a conservative management.

Additions now contemplated, coupled with the present supply works, are estimated to be sufficient for the needs of the Hartford metropolitan area for another 75-year period, if management similar to that of the past continues to function. Involved in this new planning is the progressive development of a supply from the Farmington River made possible mutually favorable compromises.

What Are Waterworks Men Doing?

FROM New England to the West Coast they are restudying, developing and modernizing their water-supply systems.

Increased consumption, drought, higher quality demands, insistently call for better and more ample water service. These requirements are being met in many ways, as dictated by the local hydrology, structure and topography. Careful financing, more efficient management and the application of modern business procedure are keeping pace with other improvements in the waterworks industry, as exemplified by the group of articles presented in this issue.

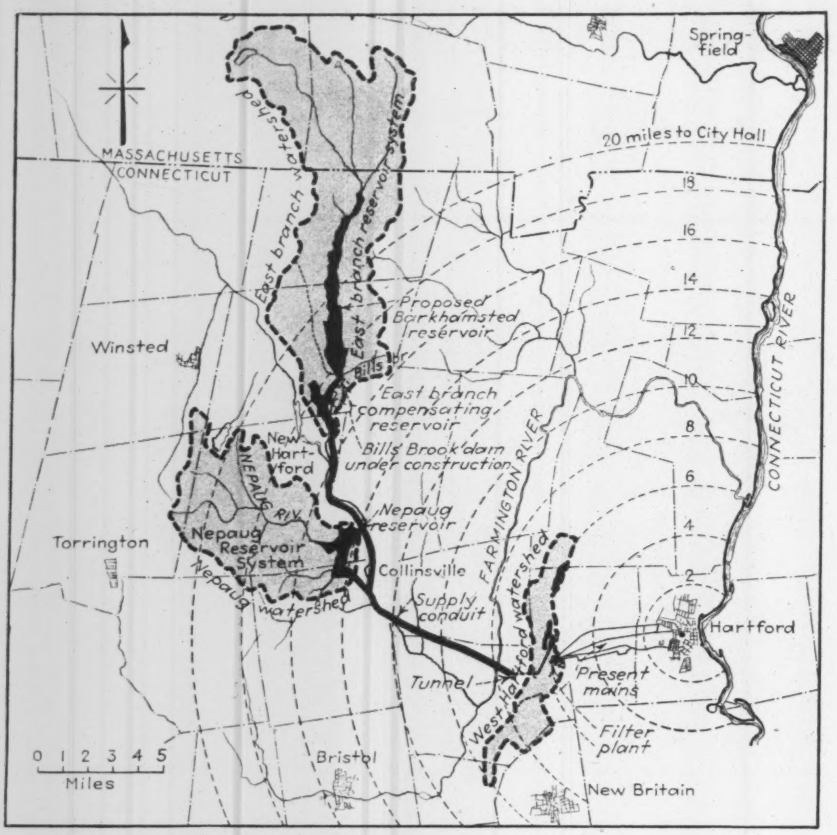


FIG. 2—RESERVOIRS AND WATERSHEDS of Hartford, Conn., water supply. The East Branch reservoir system is currently under development.

with hydro and industrial interests settled out of court.

A feature of the immediate development includes the 155-ft. $2,000,000 Bills Brook earth dam, in the design and construction of which geophysical underground explorations played an important rôle. Model experiments determined the design of the spillway. Besides the construction of the dam, the authorized plans include the following: 20 miles of new highway, removal of 1,325 interments in three cemeteries, clearing the reservoir site, outlet-flow conduits to Nepaug Reservoir and purchase of land to regulate sanitary control.

The authority in voting for the water-supply work made available $8,600,000 and included, in addition to the proposed reservoir developments and its connections, construction of additions to the filter plant, a balancing reservoir near the city and additions to the distribution system. Excellent credit permitted financing to be done normally without federal assistance.

Selection of new supply sources

The first improvement in Hartford's water system dates back to 1867 when, after fourteen years' experience with water from the Connecticut River, an upland source of supply with gravity service was installed. These supply works, consisting of several side-hill reservoirs on the easterly side of a low range of hills, 6 miles west of the city, served their purpose until 1914. Portions of them are an integral part of the present supply works.

As early as 1900 it was realized that the sources of supply were inadequate for the needs of the growing city, and several investigations were made for additional facilities during the succeeding decade. The most promising of the localities studied was found in tributaries of the Farmington River, a stream of 600 square miles' drainage area, having its rise in Massachusetts and flowing in a generally southeasterly direction into the Connecticut River at Windsor, about 6 miles north of Hartford. While excellently well conditioned for water-supply purposes, this stream was highly developed for power purposes, with several thriving communities along its course that were entirely dependent for livelihood upon the industries using water power.

Two localities in particular were considered for water-supply development: one on the Nepaug River, a small tributary from the west about a mile above the village of Collinsville, the other on the East Branch about a mile east of the town center of New Hartford. The first of these was 9 miles northwest of the original supply works at West Hartford, and the second was 4 miles north of the first. At each of these places conditions were favorable for storage reservoir construction of such size that adequate storage could be provided for the tributary drainage above; the first has a 31-square mile drainage area, and the latter had about double that area. After considerable study the Nepaug site was chosen and preparations were made for its development.

In 1909, application was made to the General Assembly for authority to divert the water of the Nepaug River and several smaller streams for use of the city of Hartford. The matter at once aroused considerable opposition from the riparian owners, and the bill was rejected by the legislature.

Riparian owner compromise

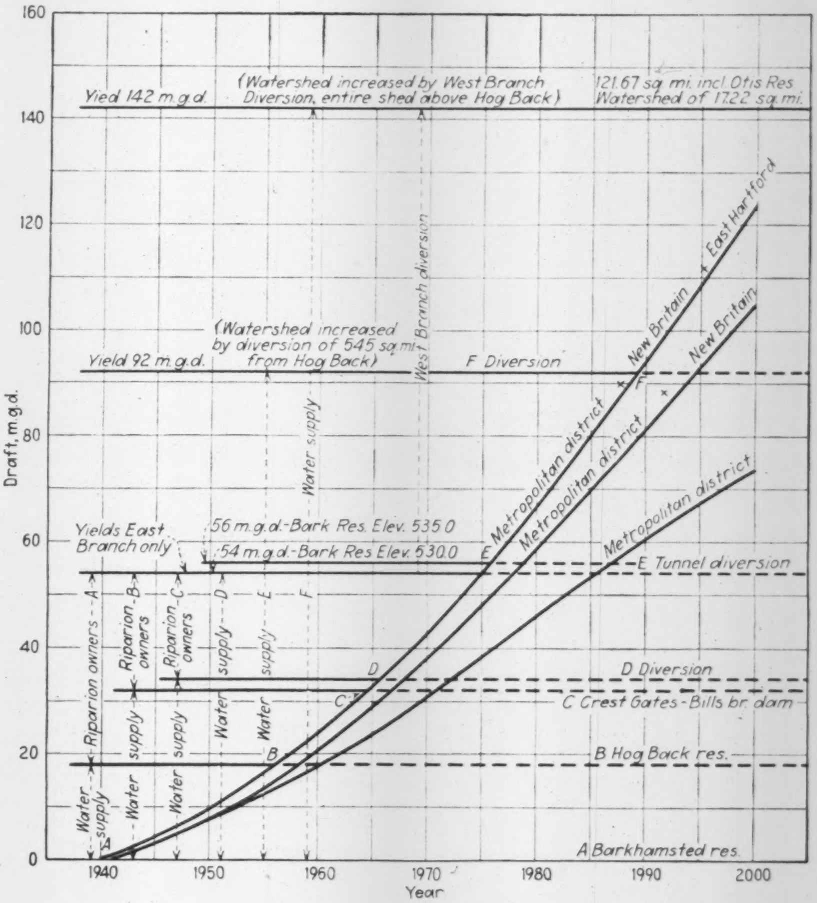
At the next meeting of the General Assembly an amicable agreement was brought about in which it was decided that the private interests should withdraw opposition to the water-diversion plan if the city authorities agreed to construct a "compensating" reservoir on the East Branch of the Farmington River for the sole purpose of stream regulation. The proposed compensating reservoir was to have a capacity of 3,000-m.g. storage (roughly 100 m.g. per square mile of diverted area), tributary to which was 62 square miles of drainage area. Among other requirements of the agreement was a clause which provided that the city would never take the East Branch for water-supply purposes. However, within nineteen years of the start of construction of the

PRESENT UNIT PRICES ON COMPARABLE STRUCTURES NEAR HARTFORD, NOW AND 29 YEARS AGO

	First Contract, Bills Brook Dam, Awarded June 21, 1935				Second Contract, Bills Brook Dam, Awarded July 21, 1933				Richards Corner Dam, Awarded Aug. 10, 1915			
Description	Quantity, Cu. Yd.	Lowest	Highest	Average	Quantity, Cu. Yd.	Lowest	Highest	Average	Quantity, Cu. Yd.	Lowest	Highest	Average
Earth excavation	110,000	*.18	1.00	.35	120,000	.29	.60	.39	140,000	*.35	.65	.48
Riprap	25,000	.95	2.50	1.60	2,700	*1.00	3.25	2.06	1,000	1.00	3.00	1.71
General fill—12" layers	500,000	*.23	.40	.30	350,000	.20	.49	.31	180,000	*.27	.90	.46
General fill—8" layers	140,000	*.23	.40	.31	85,000	.23	.69	.36	180,000	*.27	.90	.46
Soil core and blanket	75,000	.40	.99	.62	75,000	.22	.78	.45	85,000	.40	1.00	.61
Selected fill—6" layers	45,000	*.28	.45	.33	20,000	.23	.65	.41	85,000	.40	1.00	.61
Concrete corewall	21,000	4.00	7.00	5.01	16,500	3.89	6.90	5.28	15,700	3.00	5.00	4.11
Portland cement, bbl	28,000	2.25	2.75	2.46	37,000	2.29	2.95	2.39	25,000	1.50	2.10	1.71

Note—The lowest prices tabulated above are not necessarily bid prices of the lowest bidder. Those marked with a star are prices of the lowest bidder.

FIG. 3—SEQUENCE of future development for additional water supply for Metropolitan District of Hartford, Conn. Estimated draft from Barkhamsted Reservoir and yields under various conditions are shown.



Nepaug development, another construction contract was signed as the first step in the development of the prohibited East Branch source of water supply for the Hartford Metropolitan District.

One of the most interesting and, in some ways remarkable, features of both of these developments was the amicable and satisfactory adjustment of the power-right problem in which five independent corporations were involved. In this first case Hartford obtained an additional water-supply source estimated to yield 20 m.g.d. in time of drought, and the riparian owners had a regulated stream with accumulated storage. The settlement of the diversion problem by cooperation rather than by court action and cash payment resulted in great money-saving to the Metropolitan District and gained for the riparian owners an increase in firm power at their plants.

The former cooperative plan worked out to such mutual advantage to the district and to riparian owners that when plans were made for additional development in the territory that had been inviolate under the previous contract satisfactory modification of the agreement was achieved with what again appear to be mutual benefits.

East Branch project

The development of the East Branch drainage area as a source of water supply may be called the third step in the water program for the Hartford district and its dependencies; and this development, regardless of the water-power factor together with present developed or available supplies in the district, is estimated to be sufficient in time of extreme drought for the supply of 755,000 people, using 124 gal. per day per capita, a condition that may be anticipated not earlier than 1975 (See Fig. 3. The present population of the district, including the Hartford Metropolitan District, New Britain and East Hartford, is estimated at 308,690, using about 28 m.g.d., or 91 gal. per capita.

Curved earth dam

The principal construction feature of the development now under way comprise the Bills Brook Dam, forming the Barkhamsted Reservoir. The design of the dam embankment gives a maximum width of 900 ft. at the base and 1,285 ft. at ordinary high-water level (El. 530). The extreme length is about a half mile. In plan the dam is slightly

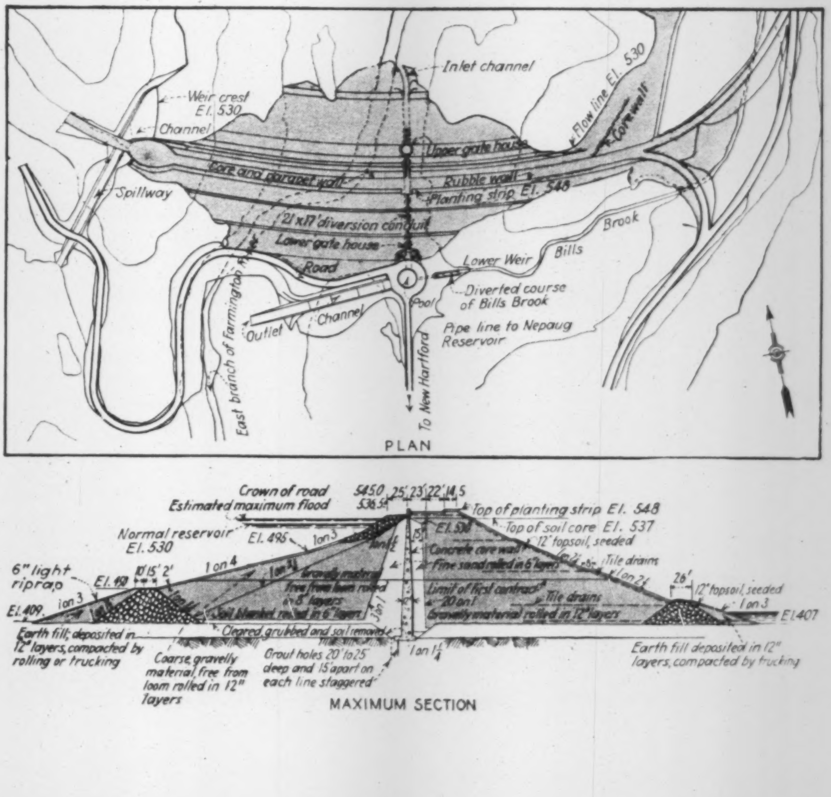

Inlet channel
Weir crest El. 530
Channel
Flow line El. 530
Corewall
Upper gate house
Core and parapet wall
Rubble wall
Planting strip El. 548
Spillway
21'x17' diversion conduit
Lower gate house
Road
Brook
Bills
Lower Weir
Diverted course of Bills Brook
Pool
Outlet
Channel
Pipe line to Nepaug Reservoir
East branch of Farmington R.
To New Hartford
PLAN
Crown of road
Estimated maximum flood
545.0
536.5
25' 23' 22' 14.5
Top of planting strip El. 548
Top of soil core El. 537
Normal reservoir El. 530
El. 495
1 on 3
El. 538
15'
Concrete core wall
Fine sand rolled in 6" layers
12" topsoil, seeded
1 on 2
Tile drains
1 on 2½
6" light riprap
El. 490
10' 15' 2'
1 on 4
1 on 3½
Gravelly material free from loam rolled in 8" layers
Limit of first contract
20 on 1
Tile drains
Gravelly material rolled in 12" layers
26'
12" topsoil, seeded
1 on 3
El. 409
1 on 3
Soil blanket rolled in 6" layers
3 on 1
El. 407
Earth fill; deposited in 12" layers, compacted by rolling or trucking
Cleared, grubbed and soil removed
Coarse, gravelly material, free from loam rolled in 12" layers
Grout holes 20' to 25' deep and 15' apart on each line staggered
1 on 1¼
Earth fill deposited in 12" layers, compacted by trucking
MAXIMUM SECTION

FIG. 4—BILLS BROOK DAM, now under construction, is an earth embankment with a concrete corewall. Maximum section indicates location and classification of different materials.

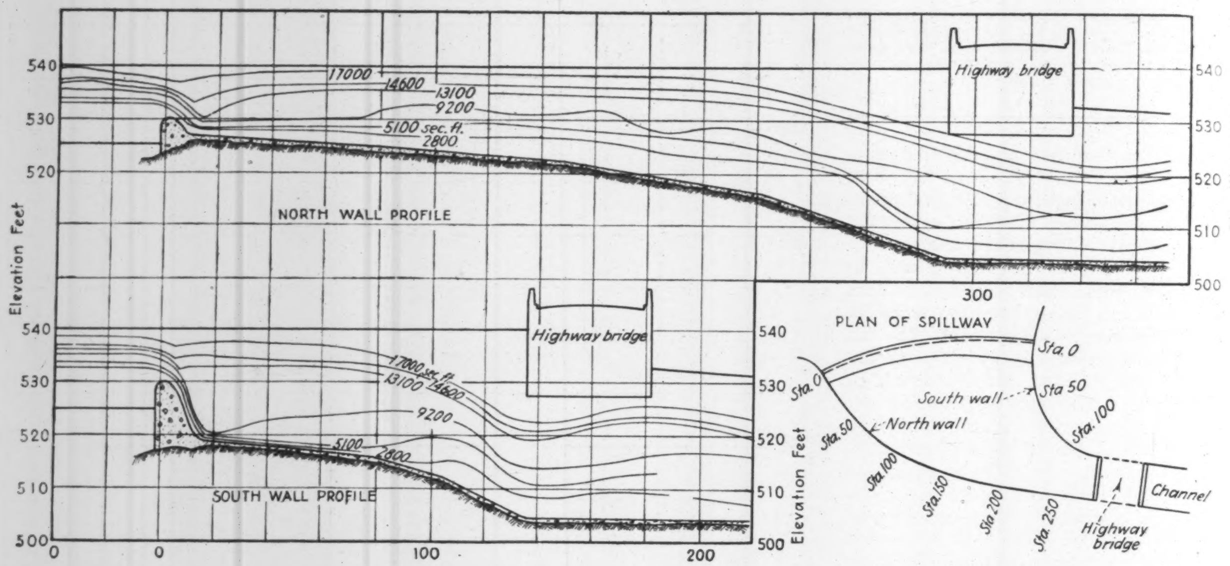


FIG. 6—MODEL indication of spillway profiles of water with various quantities flowing down the channel.

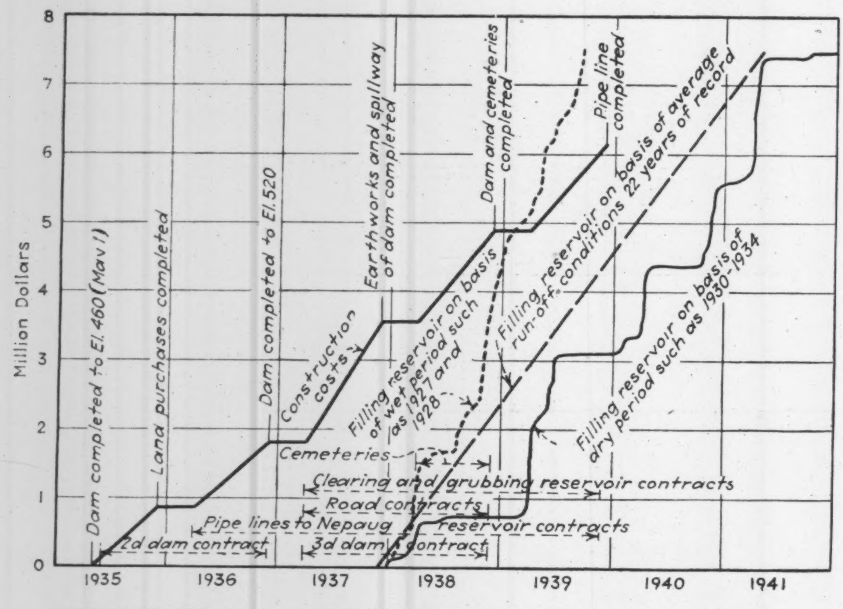


FIG. 5—BEFORE five-year construction program completed, it is planned to start filling the reservoir; maximum, minimum and average filling possibilities are shown. Annual expenditures range from $866,000 in 1936 to a $1,763,000 in 1937.

curved downstream, in order to form an attractive blending with the natural topography. The maximum height above streambed is 137 ft., and depth to lowest foundations is 18 ft. The top of the dam (roadway level El. 545) is 60 ft. wide, showing freeboard for ordinary conditions of 15 ft., and the slopes on the upstream face vary from 1 on 4 at the bottom to 1 on 1.5 at the extreme top. Both upstream and downstream toes abut against heavy rockfills with slopes of 1 on 1½ outside. The outer face of these fills was covered with well-compacted soil to a slope of 1 on 3 and covered with riprap. The rockfills and facing serve the double purpose of abutments for the dam and as cofferdams for control of the stream during construction.

The principal quantities involved are 1,500,000 cu. yd. of fill, 44,000 cu. yd. of concrete in the corewall, 50,000 cu. yd. of riprap, and 55,000 cu. yd. of rock and broken-stone filling.

Soil investigations were undertaken, to determine whether a hydraulic fill or an earth embankment with or without a concrete corewall was the most desirable type of structure. The result of these investigations and reports by Prof. Charles Terzaghi and Prof. Charles Berkey determined the type adopted. The conclusions were based not only on surface and subsurface examination but on thorough exploration by diamond drill and deep test pits as well as by a careful exploration using geophysical methods.

Spillway model

The design of the spillway was worked out by means of models built at the Worcester Polytechnic Institute, by Prof. Charles M. Allen, and based on discharge records of the watershed covering 23 years' observation and experience in southern New England over nearly a century. Fig. 6 shows the surface elevation of the water in the spillway under various discharges, including the maximum of 17,000 sec.-ft. The results obtained from the model tests, besides checking the design as worked out in the drafting room and observations during the testing, suggested a change in the bottom of the channel that resulted in savings in construction work, which more than offset the testing costs.

Underground surveys

The underground study for best location was carried out by means of test pits, wash borings, diamond drilling and an electrical resistance survey by the Schlumberger process (*ENR*, Aug. 15, 1935, p. 228).

The ground-surface area of 62 acres was laid out in 125x100-ft. parallelograms, and readings were obtained at each corner. Altogether, 243 electrical determinations were made and the results plotted on a contour map of the rock bed of the section of the valley under consideration. After the plot was made, the best location for the dam was determined, over which a check line of 49 diamond-drill borings was made. The average depth to rock by boring was found to be 40.4 ft., while the electrical measurements predicted an average of 39 ft. The diamond-drill holes ranged from 11 to 148 ft. in depth, and while the maximum deviation between the two methods in individual cases amounted to as much as 38 ft. at the deepest hole, the ordinary difference was from 5 to 10 ft. The electrical survey disclosed a deep pre-glacial gorge at the extreme east end of the dam site and beyond the limits of construction work, which under usual methods of exploration, would probably not have been revealed. Subsequent investigations gave assurance that the filling of this gorge was of such a character as to warrant the assumption of its impermeability.

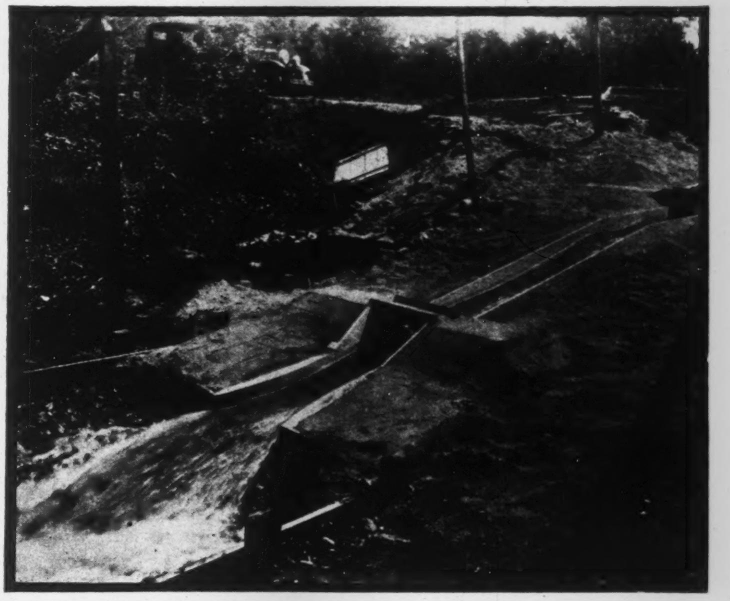


FIG. 7—DISCHARGE FROM APRON at end of model spillway created no erosion from back-current.

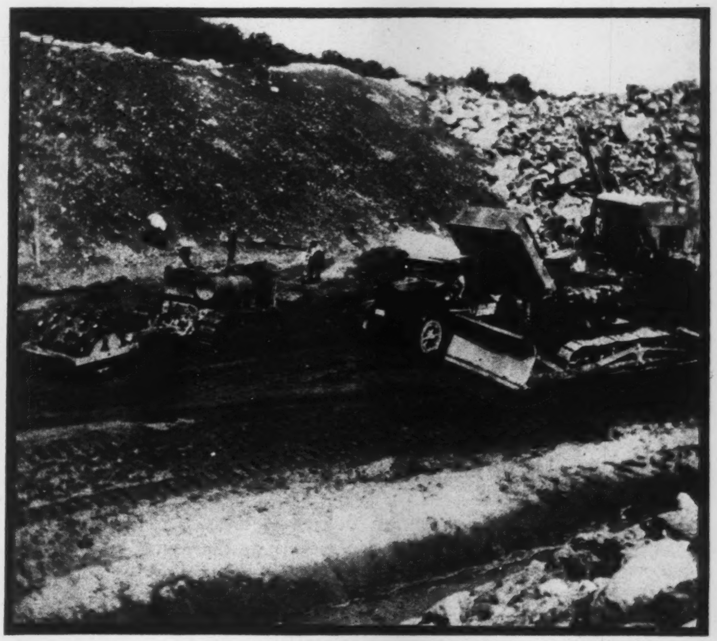


FIG. 8—TRUCKS, bulldozers and sheepsfoot rollers place and compact earthfill on Bills Brook Dam.

Concrete placed by pumping

Concrete for the dam was proportioned by weight, mixed for $1\frac{1}{2}$ min. on a 1-yd. mixer and delivered through a short, inclined chute to a 2-yd. remixing hopper with a series of paddles which revolved slowly to prevent segregation of aggregates. The base of this hopper was connected to the concrete pump, which discharged through a toggle-jointed pipe line made up of sections of 7-in. steel pipe of various lengths up to 10-ft.

Concrete delivered was excellent after the plant was gotten into working condition and the operating force became familiar with its use. One desirable accompaniment of this method is its automatic aid in getting a good consistency of concrete. If the mass is too sloppy, the aggregate settles to the bottom of the pipe line; if the mass is too stiff, it plugs the pipe line; but in either case, delivery is stopped. In the 28,000 cu. yd. placed, the average rate of delivery was 25 yd. per hour, with a maximum of 35 yd. The longest distance was 850 ft. and the maximum lift 20 ft.

Corewall concrete of 2,000 lb. compressive strength used a 1:7 mix with $7\frac{1}{2}$ gal. of water and aggregate of 6.5 fineness modulus. The use of the water-cement ratio in designing an earlier structure (1914) would have produced equally strong concrete with a saving of approximately 7,800 bbl. of cement on that work.

The carefully conceived and conservative financing procedure of the new water department project is also of interest. Authorization for proceeding with the work has been given in such a manner that contract commitments can be made of such amounts only as will be safely within the ability of the water bureau to finance from its fluctuating income.

Following Connecticut tradition, it seemed best to utilize local resources as far as possible before seeking outside help, and to proceed only so fast with commitments as conservatism dictated. In 1933, serial 40-year $3\frac{1}{2}$ per cent bonds in an amount of $1,000,000 were sold at a slight premium of $2,020 and provided money for the first contract. In 1935 a second contract was financed by sale of $1,600,000, $2\frac{1}{4}$ per cent bonds sold for $1,598,340. By this method of financing all of the work on these contracts is under the direct and sole control of the water bureau.

So far as is apparent at the present time, this course has resulted in ultimate economy in capital expense and increased efficiency in construction work. No change was made, or is contemplated in the water rates established in 1926. The management has been such as to provide for all demands of capital increase as well as maintenance and operating expense.

The work on the dam was planned in three sections, each of which, so far as it went, would be complete in itself in case storage facilities were required before the completion of the entire work.

The first section of the work, completed in May by C. & R. Construction Co. of Boston, for $538,755, carried the completed dam to El. 460—i.e., 50 ft. above river level and included some of the important works, such as river control, deep foundation for corewall and the beginnings of the gate chamber. The second contract was awarded to

B. Perini & Sons, Inc., of Framingham, Mass., whose bid for the work was $550,778.50, carrying the embankment to El. 520.

An analysis of the bids received for the work on these two contracts and another for similar work twenty years ago in the same locality (Table 1), all of which are strictly comparable in major features, raises the question as to whether contractors for public works are principally interested in being successful bidders or if there actually is such a vast difference in the ability of different contractors to carry on work.

It was estimated that the total cost of the dam would be somewhat ov $2,000,000 and the construction wo would extend over a period of five six years. Due to the desirability proceeding by parts rather than as whole, the time of completion has bee lengthened. The revised program w made out on Jan. 1, 1935.

Friction Tests in New Cast-Iron Centrifugally Formed Pipe

LOSS-OF-HEAD TESTS conducted by the Caldwell Engineering Co. on the new transmission system of the Six-Town Project, south of Springfield, Ill., indicate higher coefficients (134 to 145 for *C* in Hazen-Williams formula) than are usually obtained. These high figures are attributed to smoother interiors and longer pipe lengths. This system, serving the towns of Chatham, Auburn, Virden, Girard, Pawnee and Divernon, has recently been installed and offered favorable characteristics for testing. The transmission lines traverse a level prairie country and have long straight sections of pipe ranging in length from 1.3 to 6.4 miles.

All pipes were Class 150-lb. centrifugal cast iron in 18-ft. lengths with joints made with braided jute and a jointing compound. The test section of 12-in. main was 6.4 miles in length, extending over a level terrain in a straight line. It contained five tees and two valves. With eleven different velocities, varying from 2 down to 0.825 f.p.s., *C* averaged 145, varying from 140 to 147, the variation bearing little relation to velocity.

The test section of 10-in. main was 4.3 miles in length. The line had a slight curve and one creek crossing which required four 22½-deg. ells. The only other fittings were one valve and one tee. On this section, at nine velocities varying from 3.14 to 1.31 f.p.s., *C* varied from 145 to 149, averaging 146.

A section of 8-in. main, 1.3 miles in length, laid without any fittings was tested at six velocities varying from 3.58 to 1.26 f.p.s. The coefficients, averaging 142, had a minimum value of *C* at 135 and a maximum of 146.

The test section of 6-in. main was 2.9 miles in length and it had two long-radius horizontal curves and one vertical curve which were made by a slight swing in the joints. The line did not have any ells or other fittings. Five velocities varying from 3.89 to 2.07 f.p.s. were all close together, 133 to 135, and averaged 134.

The loss of head was measured by calibrated gages equipped with a tee and valve for blowing out the column, to eliminate air from the piping and gage. The pumpage was measured by a simplex meter for the tests on the 12-, 10- and 8-in. lines and by a 4-in. turbine meter for the tests on the 6-in. line.

The test procedure was to start up the pump at the booster station, and after the flow had become steady to take a series of readings, then cramp off the pump discharge valve; after the flow had become steady, another series of readings would be taken. About 30 min. or more was required for one set of readings, and the tests were carried on over a period of two weeks.

Chlorination of Shellfish Area Charged to Municipalities

POLLUTION of the tidal flats by sewage from eleven cities and towns in the Merrimac Valley of Massachusetts led several years ago to the construction of a chlorination plant on Plum Island, near Newburyport, for sterilization of water from which clams are harvested. In response to an order of the supreme court of Massachusetts, a commission headed by Joseph Riley of Boston has reported on the proper allocation of plant costs among the municipalities responsible for the pollution. The Massachusetts department of public health cooperated in the study.

The commission's allocation is arrived at by taking the average daily water consumption and the figure representing the population of each city and town contributing to the pollution, dividing each by a figure equivalent to double the number of miles by which each municipality is distant from the flats, and averaging the resulting percentages. Consideration of the distance of these places from the flats is necessary, because the commission finds that a great part of the pollution entering the river from the cities and towns upstream is purified by natural processes before the water reaches the flats, and that the pollution from each place is decreased by every mile that the river flows toward the flats from the point of sewage introduction.

An example of the method used is afforded by the accompanying table, which includes six of the eleven municipalities concerned. Places of different sizes and various distances from the flats are shown, to indicate how the computations were made. The percentages finally allocated were: Chelmsford, 0.3; Lowell, 8.9; Dracut, 0.5; Lawrence, 10; Methuen, 2.5; Andover, 1.6; North Andover, 0.9; Haverhill, 10.4; Amesbury, 6.5; Newburyport, 46.2; Salisbury, 12.2. Total, 100.

TYPICAL DETERMINATIONS IN ALLOCATION OF PURIFICATION COSTS

Municipality	Aver. Daily Water Consumed, Gal. (a)	Double the Distance to Flats, Miles (b)	Quotient a/b	Per Cent of Total Quotients	Population (c)	Quotient c/b	Per Cent of Total Quotients
Lowell	5,706,000	37.9	150,554	7.835	100,234	2,645	9.932
Lawrence	4,557,000	27.9	163,333	8.5	85,068	3,049	11.449
Andover	899,000	26.6	33,797	1.759	9,969	375	1.048
Haverhill	3,608,000	17.9	201,564	10.489	48,710	2,721	10.217
Newburyport	1,220,000	1.3	938,462	48.837	15,084	11,603	43.57
Salisbury	216,000	0.8	270,000	14.051	2,194	2,743	10.3
Total quotients (11 municipalities)			1,921,612	100.00		26,631	100.00

The final allocated percentage of cost specified for each community is the average of the above percentage columns: thus, Lowell's is 8.9, the mean of 7.835 and 9.932.

Denver Goes to West Slope for Additional Water Supply

Pacific-bound waters from Fraser River and tributaries will be diverted eastward through enlarged pioneer bore of the Moffat Tunnel under Continental Divide by next May, according to schedules of work now under way

For years the city of Denver, Colo., has depended upon the steep and narrow watersheds of the east slope of the Front Range of the Rocky Mountains for its water; long ago it exhausted all possible new sources in that area. The South Platte River and its tributaries are the present sources of supply, but prior water rights of irrigation districts in the plains to the east preclude further development of these streams. The only alternative, now that additional water is needed, is to cross the Continental Divide and tap new and unclaimed sources of supply high in the West Slope area. From several schemes long under study that for diverting the flow of the Fraser River and its tributaries through the divide at an elevation of about 9,000 ft. seemed most practicable. The driving of the Moffat Railroad tunnel in this area by the pioneer bore method provided an ideal means of diversion, which was quickly taken advantage of by the city. Since the completion of the railroad tunnel early in 1928 the Moffat diversion project has passed through hectic periods of planning and financing. But now diversion is close to a reality, for construction is under way and according to present schedules the first waters will flow through the converted pioneer tunnel by next May.

General plan

The plan being carried out contemplates an annual diversion of 54,600 acre-ft. from the Fraser and its tributaries—Jim Creek, Big and Little Vasquez Creeks and Ranch Creek. Through a system of diversion dams and collecting canals, waters of these streams will be brought to the top of an inclined shaft 214 ft. above the pioneer tunnel. The shaft will intercept the tunnel 2,700 ft. east of the west portal, and will provide the necessary head to force the water over the apex of the tunnel, 153 ft. higher than the west portal.

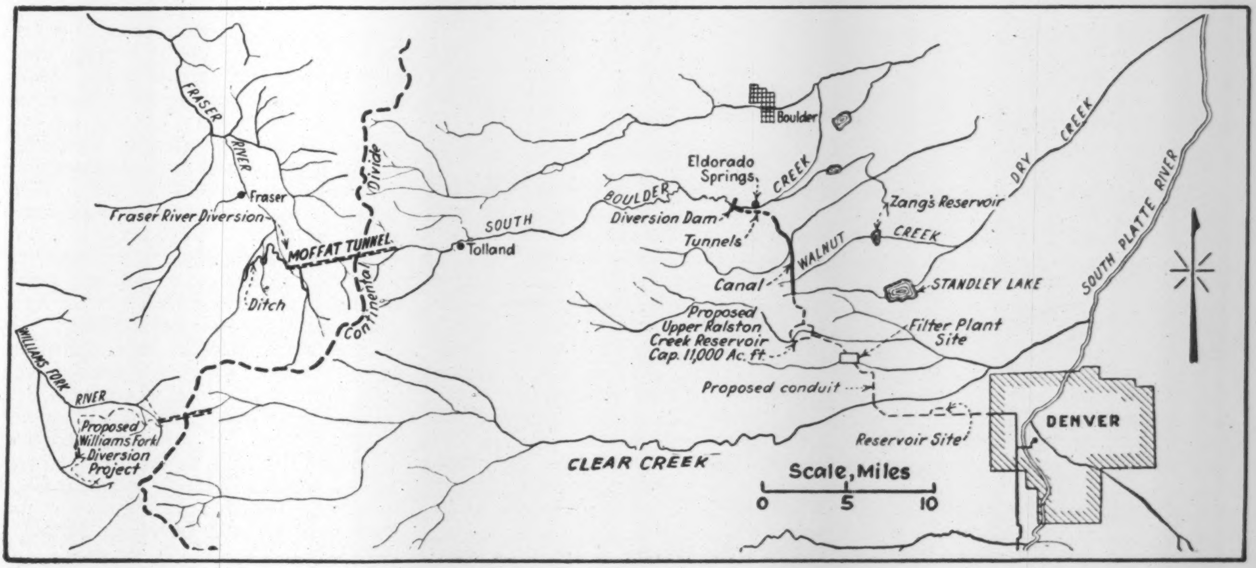
From the eastern end of the 6.2-mile pioneer tunnel, the diverted waters will flow through concrete and stone-paved channels to South Boulder Creek. Some 20 miles downstream and 3 miles above Eldorado Springs in South Boulder Gorge, a dam will divert Denver's share of the creek flow southward (toward the city) into 6 miles of tunnels and conduits to the headwaters of Dry Creek, a tributary of the South Platte.

Some day the city will build an 11,000-acre-ft. reservoir and a filter plant in this area, and thence connect the supply by conduit to the present municipal distribution system. However, a water-exchange agreement with an irrigation district on the Platte below Denver will enable the city to augment its present supply without building the reservoir or making a physical connection to its distribution system. The district owns water rights on the Platte far enough above Denver to allow the city to use that water in exchange for the amount turned into the river through Dry Creek from the Moffat diversion.

Tunnel-maintenance history

Maintenance of the pioneer tunnel since its completion and its conversion to a suitable water conduit are of interest because of the difficulties involved. The pioneer tunnel, 32,388 ft. long, was driven up grade from both portals to an apex 18,682 ft. east of the west end. West of the apex the rock is disintegrated and fissured to such an extent that continuous lining of concrete is required for the water tunnel. This section traverses the now-famous Ranch Creek Fault, a badly shattered squeezing ground that caused no end of trouble in the larger railroad bore and required steel-beam timbering and heavy concrete lining. All of this west section of the pioneer bore was timbered when driven. From the apex to the east portal the rock, for the most part, is sound, and the tunnel was originally timbered in only a few places, aggregat-

BRINGING FRASER RIVER WATER under the Continental Divide via the Moffat Tunnel, then down South Boulder Creek and by diversion canal into a tributary of the South Platte, Denver is enabled to exchange this water for an irrigation district's water rights upstream on the South Platte, to augment its present supply.



ing about 10 per cent of the total length.

The pioneer bore was driven in 8x8-ft. and 8x9-ft. sizes. To provide the required capacity for the aqueduct, the tunnel will be enlarged throughout to 10½-ft. circular section inside of lining. Present plans call for the enlarging and lining of the portion eastward from the bottom of the shaft to the apex, 16,000 ft., and the portions east of the apex that were originally timbered. The remainder of the east section, where the tunnel now is 8x8 ft. square in good rock, will not be enlarged or lined at this time.

For eighteen months after completion of the pioneer tunnel early in 1928, it was maintained by its builders, the Moffat Tunnel Commission. This commission is a public body representing the Moffat Tunnel District, which comprises the city of Denver and the territory served by the Denver & Salt Lake (Moffat) Railroad, and was created for the purpose of financing the railroad tunnel.

In this period the commission directed most of its efforts toward keeping the Ranch Creek Fault section from closing up. Some 1,500 lin.-ft. of timber work was eventually removed, the bore enlarged to circular section and lined with pressed steel plates. These plates alone were insufficient to hold the ground, and 1x3-in. steel ribs were added as stiffeners between rings of plates. Then the entire length of steel-plate lining was covered with 6 in. of air-applied concrete, 600 ft. of it reinforced.

Water Board assumes control

In September, 1929, the pioneer tunnel was taken over by the Denver Board of Water Commissioners. Soon afterward a board of consulting engineers, consisting of Herbert S. Crocker, Geo. M. Bull and George Lewis, all of Denver, was appointed to prepare plans and to develop the complete diversion project.

In the period 1929-1934, the Water Board enlarged and lined with pressed-steel plates (covered with ¾ in. of air-applied concrete) 7,000 ft. of tunnel by day-labor methods. In addition, 4,000 ft. was enlarged without lining.

An almost complete lack of snowfall on the East Slope in the winter of 1932-33 threatened Denver with a serious water shortage. The situation became so acute that desperate attempts were made early that spring to provide for emergency diversion. Marshalling a large force of workmen in the bitter weather of the high altitudes, the Water Board started sinking the shaft, constructing the Fraser River diversion dam and building a temporary pipe line between the dam and shaft, a distance of 15,000 ft. At that time the tunnel was in shape to carry a considerable flow.

All of these frantic preparations were suddenly stopped in April, 1933, when a 6½-ft. snowfall in 36 hours on the East Slope ended all fears of a water shortage.

Orderly work resumed

After quitting the emergency measures, the Water Board resumed work on its orderly plan. A pilot shaft was sunk and timbered at the site of the intake, and the tunnel section east of the apex was given attention, most of the timber was removed, and the timbered places were enlarged and lined with steel plates protected with ¾ in. of air-applied concrete. On the west section some 2,000 ft. of tunnel, beyond that actually enlarged, was ring-drilled for blasting. On March 1, 1934, with federal financial assistance in sight, the Water Board discontinued all of its day-labor operations. Up to this time $1,100,000 had been spent on maintenance and enlargement.

Financing

The present work is being carried out under an unusual PWA financial arrangement—a lease agreement for an expenditure of $3,500,000 (*ENR*, Dec. 6, 1934, p. 730). First application for PWA funds was made Oct. 1, 1933, but it was a year later, Nov. 9, 1934, that the final agreement was made. The city has deeded all of the property and rights concerned in the diversion to the PWA, which, in turn, will lease the property back to the city for a term of 30 years at an annual rental of $175,000. This amount is sufficient to pay 4 per cent interest and to amortize rent certificates issued by the city to pay 70 per cent of the loan-and-grant money expended. The redemption money will come solely from water revenues, as the rent certificates are not secured by the faith and credit of the city.

Originally it was intended to ask PWA for $8,000,000, which would have financed the diversion project complete, including the lower reservoirs, the filter plant and the conduit to the city. However, the impossibility of completing the entire project within the two-year time limit required by PWA regulations led to the decision to omit the lower works at present.

Contracts let

As soon as the financing was arranged for, bids were taken for the completion of the enlargement and for installing reinforced-concrete lining in the pioneer tunnel, and for completing the shaft, to be lined with concrete. Contract for this work was awarded early in January of this year to the Utah-Bechtel-Morrison-Kaiser Co., a combination of western construction firms. The contractors have continued the work prosecuted for so long by the Water Board and now have the tunnel ready for the reinforced-concrete lining. The sinking of the shaft is also under way.

From the bottom of the shaft westward to the west portal the original tunnel is not being enlarged. Instead, concrete lining of 5-ft. 8-in. inside diameter is being placed for access purposes only.

When the present work is completed, the pioneer tunnel will contain the following lengths of various types of lining, including that placed by the Moffat Tunnel Commission: steel liner plate, 6-in. air-applied concrete and 13-in. reinforced concrete—1,502 ft.; steel-plate lining, thin air-applied concrete, 12½-in. reinforced concrete—5,992 ft.; 12½-in. reinforced concrete—5,601 ft.; 6-in. reinforced concrete—3,406 ft.; all above is 10½-ft. inside diameter; 5-ft. 8-in. diameter, reinforced concrete—2,700 ft.; shaft, 9-ft. 5-in. inside diameter, 214-ft. vertical height on 50-deg. slope.

Contracts were let this summer to A. S. Horner, Denver, for the Eldorado Springs diversion dam and to the Utah-Bechtel-Morrison-Kaiser Co. for 7,000 ft. of lower diversion tunnels, 15,000 ft. of lined canal between the Fraser diversion dam and the shaft. Bids will be taken early in September for 18,000 ft. of unlined canal in the Rocky Flats area at the head of Dry Creek. In October bids will probably be called for a 2,200-ft. tunnel for the Vasquez Creeks branch of the project. Siphons and canals for this part of the project will be put under construction next year.

Direction

The Moffat diversion project is being carried out under the Denver Board of Water Commissioners, the consulting board mentioned above, and A. A. Mathews, supervising engineer, Orman M. Strange, field engineer, and E. H. Snyder, designing engineer.

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Mexican Irrigation Project Resumed After 25 Years

After a lapse of more than 25 years since the inception of the project, construction has been started by the Mexican government on a large dam on the Nazar River near Torrean for the purpose of storing water for irrigating 315,000 acres of land in the Laguna district and other parts of the valley. The dam and canal system will cost approximately $8,000,000. It is expected that with the assurance of an ample supply of water for irrigation there will be a great expansion of cotton growing in the irrigable area of the valley of the river.

Construction also has been started on two other large dams, one on the San Juan River, not far from where it empties into the Rio Grande, which will afford water storage for irrigating 128,000 acres, and the other on the Yaqui River, Sonora, which will supply water for 300,000 acres. The total expenditures for the three projects will be about $19,500,000 (U.S.).

Groundwater Relieves Drought Emergency

When insufficient snowfall on mountain watershed drastically curtailed the 1934 water supply of Salt Lake City, underground supplies were drawn upon to meet the situation

By G. H. Taylor and R. M. Leggette
Associate Engineer and Associate Geologist, Respectively,
U. S. Geological Survey, Salt Lake City, Utah

VITALLY IMPORTANT in the prevention of a water famine was the development of new underground sources of water supply in the arid basin in which Salt Lake City is located. The drought of 1931 gave warning that the city's supply from stream sources might be endangered, and a cooperative two-year agreement with the U. S. Geological Survey in 1931 provided for an investigation with recommendations as to feasible utilization of underground water resources. In May, 1934, the city officials recognized that an emergency existed that could be met only by securing an additional water supply. Guided by the studies of the Geological Survey, they drilled seventeen wells, whose yield exceeded the required amount. The successful development is described as a current illustration of the increasing importance of groundwaters in water supply. Recognition of their importance is found in a recent enactment of the Utah legislature that makes all water the property of the state under the supervision of the state engineer.—Editor.

SALT LAKE CITY, with a population of more than 140,000, lies about 4,300 ft. above sea level at the foot of Wasatch Mountains in the northeastern part of the Jordan Valley of Utah. Six major streams enter the valley from the Wasatch Mountains, while only small amounts of surface drainage come from the Oquirrh Mountains on the west. Utah Lake, lying south of the Jordan Valley, originally drained into Great Salt Lake through the Jordan River and Jordan Valley, but no gravity flow from Utah Lake has occurred since the early nineteen hundreds. The first settlers of the valley were the Mormons, or members of the Church of the Latter Day Saints, and they named the Jordan River because, like the Jordan of Palestine, it drains a fresh-water lake into a dead sea—Great Salt Lake, lying just northwest of the Jordan Valley.

The development of the water supply of Salt Lake City dates back to the first settlement of the valley in 1847, when dependence was placed upon the streams flowing down from the mountains for both domestic and irrigation use. As the city grew in population, an independently owned water supply became necessary, and exclusive rights were established on City Creek. Additional water rights were acquired on other mountain streams entering the valley, and small storage reservoirs were constructed on some of the streams. Settlers along the streams had also acquired rights upon the streams for domestic and irrigation use, and finally the city could find no more unappropriated water in the streams to satisfy its evergrowing demands.

Until recent years there was plenty of water in Utah Lake suitable for irrigation (but not for domestic use).

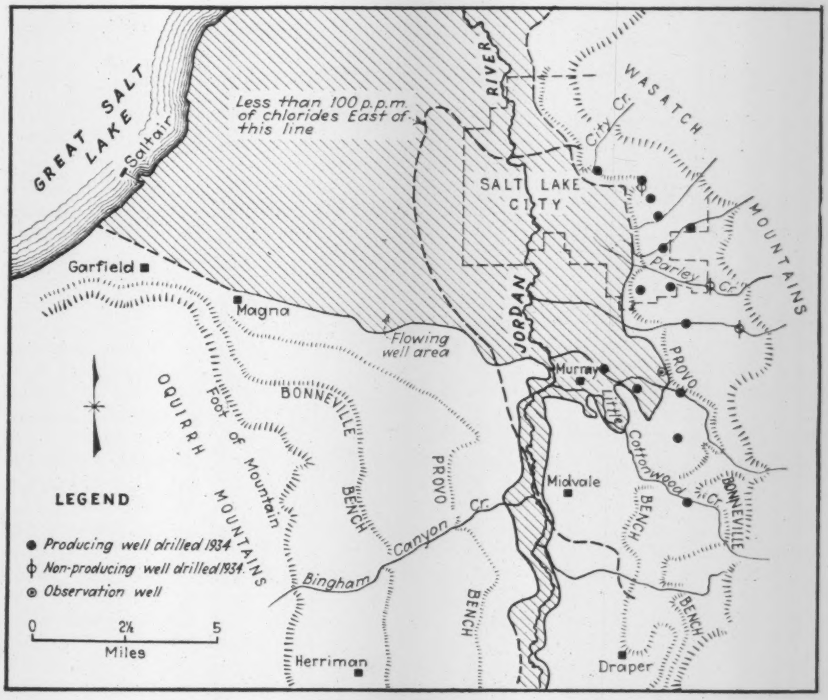


FIG. 1—ARTESIAN FLOW in the deep alluvial fill of the Jordan Valley in Utah areas, covered with the ancient shore gravels of prehistoric Lake Bonneville.

The city established water rights upon the lake and entered into exchange agreements with the irrigators on the streams in the Jordan Valley whereby the city furnished Utah Lake water to the farmers for irrigation in exchange for the mountain water that they were using. The exchange, however, was not always on an even basis, the ratio sometimes reaching as much as six parts of lake water to one part of mountain water. This was satisfactory until the recent years of low precipitation and increasing demands for water.

In 1931 the city found that, though it had very good exchange agreements, the low precipitation during the preceding winter was not enough to provide the necessary spring and summer runoff for adequate supply to the city; there was sufficient water in Utah Lake to supply the exchange water, but there was insufficient water in the mountain streams for which to make the exchange. The city therefore found it necessary to make improvements and leakage savings in its existing system, and acquired 6.5 million gallons per day of mountain water (for which exchange agreements were again entered into) and a like amount of artesian well water.

The artesian water, which was obtained by buying existing wells and included no new groundwater developments, cost about $300,000 for the purchase of land containing 137 small flowing wells, and about $450,000 for pumping facilities and related work. This marked the first extensive use of groundwater by Salt Lake City, although flowing wells had been used for private supplies since the days of early settlement.

Twenty-seven years previously, in 1904, a survey of the groundwaters of the Utah Lake and Jordan River Valleys had been made by G. B. Richardson, of the U. S. Geological Survey, the results of which were published in *Water-Supply Paper 157*. The 1931 experience, however, showed that further intensive investigation was needed. Accordingly, the city, under the leadership of Mayor John F. Bowman, entered into a cooperative agreement with the Geological Survey for a two-year investigation of the groundwaters of the Jordan Valley. The investigation was begun in 1931 and was extended for one year in 1933 and again in 1934 by Mayor Louis Marcus, successor to

Mayor Bowman, and George D. Keyser, the city's commissioner of water supply and waterworks.

Geology of valley

The Jordan Valley was originally formed by extensive faulting, which resulted in the well-known Wasatch fault. This fault, which approximately parallels the western base of the Wasatch Mountains, caused a large depression just west of the mountains. The depression was later filled with an unknown thickness of stream and lake deposits. An arm of the prehistoric Lake Bonneville occupied the Jordan Valley and left a series of terraces, the most prominent of which are termed the Bonneville and Provo benches. The Bonneville bench, formed during the highest stage of the old lake, is about 400 ft. higher than the Provo bench and 1,000 ft. higher than the present level of Great Salt Lake, which is a remnant of the ancient lake.

It is probable that the valley fill consists of many interfingering and overlapping masses of clay, sand and gravel of various shapes and sizes, laid down, resorted and redistributed in every conceivable fashion. The most permeable material apparently occurs beneath the Bonneville and Provo benches, and it is here that the largest groundwater supplies can be recovered. Some of the ancient shore gravels are exceedingly clean and permeable and yield water freely.

Water-table conditions were found to exist throughout the valley, underlain by artesian conditions in the lower areas. As Fig. 1 indicates, the groundwater moves from east and west sides of the valley toward the Jordan River and in a northwesterly direction toward Great Salt Lake. The direction of movement was established by measurements of the water levels and pressures of numerous wells throughout the valley, tied together by instrumental levels.

These measurements also showed that the principal groundwater intake area is the Bonneville and Provo benches. Numerous determinations of the chloride content of the groundwaters showed that the area of largest recharge lies on the east side of the valley and north of Dry Cottonwood Creek. The shape of the area yielding groundwater having low chloride contents also supported the conclusions of the direction of movement of the waters.

Large underground flow

It is estimated that there are about 3,500 wells in the area, the majority of which are flowing wells of 2-in. and 3-in. diameter. The greatest concentration of these wells, and of groundwater withdrawals, is east of the Jordan River, between Little Cottonwood Creek and Salt Lake City; 210 wells were found in one area of about 155 acres. In addition to this artificial discharge by wells, considerable amounts of groundwater are discharged naturally through springs and seepage, and there is an undetermined underflow in a northwesterly direction.

During November, 1932, a series of measurements showed a measurable groundwater discharge of 247 sec.-ft. (159.5 m.g.d.) to the Jordan River and through it to Great Salt Lake. It was estimated that of this amount about 160 sec.-ft. came from the artesian reservoir and the remainder from the shallow groundwater body overlying the artesian reservoir. The groundwater-fed flow of the streams entering the Jordan River from the east was more than 75 sec.-ft., of which probably about 15 sec.-ft. was the result of direct flow from artesian wells.

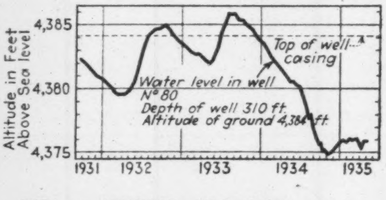


FIG. 2—ANNUAL RECHARGE of the groundwater supply occurs every year except in periods of extreme drought. Continual depletion is evidenced in the 1934 portion of the curve.

One of the most important findings of the investigation was that the area of flowing wells was practically the same in 1933 as when Richardson studied the valley in 1904; this indicates that all the intervening artesian water developments had not created a draft on the artesian reservoir sufficiently large to cause any material shrinkage of the area of artesian flow. On July 23, 1932, a preliminary report of the cooperative investigation recommended that Salt Lake City sink test wells on the Bonneville and Provo benches east of the Jordan River. This area was selected as being the most favorable because of probably greater permeability of the water-bearing materials, and because any development of groundwater in this area would be the least likely to interfere with existing flowing wells.

Threatened shortage relieved by wells

As early as February, 1934, Mr. Keyser, the city's water commissioner, in anticipation of a probable water shortage, put down the first well, which produced 1.61 m.g.d. By May 1, when it had become certain that the city's supply from the previously developed sources would be inadequate during the summer, numerous plans were suggested to obtain additional water supplies, but the city's water advisory board, under the leadership of Herbert S. Auerbach, decided that the only possibility of obtaining sufficient water in time to save the city from a serious situation was the development of groundwaters. It was thought the emergency could be met if 9.7 m.g.d. (15 sec.-ft.) of groundwater could be obtained within six weeks, provided the use of water within the city were materially restricted.

Well-drilling was hurriedly begun, partly under contract and partly by the city itself, with six drilling rigs. By Juy 1 the needed 9.7 m.g.d. was being pumped from newly drilled wells into the city's mains, and other wells were still in process of being drilled. Shortly after July 1 a well was completed which yielded 6.8 m.g.d. with a 40-ft. drawdown. This marked success gave impetus to the work, and when the program was later completed it was found that, of seventeen wells drilled, fourteen were producing, yielding a total of 29.7 m.g.d.

The total cost of the venture was about $250,000, which is less than $8,500 per million gallons per day of water obtained. The cost of the completed wells alone, ready for the final pump installation and including the non-producing wells, averaged about $5,030 per million gallons per day.

The value of this supplementary supply to the city is shown by the fact that during the summer months of 1934 as much as 59 per cent of the total supply of the city came from the wells. This was true even after consumption had been heavily curtailed, the monthly consumption during the summer of 1934 being only 60 to 80 per cent that of corresponding months of 1933. However, the wells drilled by Salt Lake City during 1934 are expected to be utilized only during periods when the surface-water supplies are inadequate or during heavy demand periods such as are occasioned by large fires. Normally the surface supplies have been sufficient, and the wells will probably be used only during the summer months of some years.

Effect of new wells

One of the most critical problems in connection with groundwater development in the Jordan River Valley relates to its possible effect on the head of the numerous flowing wells in the valley. Any well that is allowed to flow or is pumped will cause a lowering of the pressure head in the water-bearing formation in the vicinity of that well. Therefore, the discharge from new units in the flowing well area will inevitably produce marked effects on flowing wells near them. But wells that are located on the Bonneville and Provo benches have the advantage of drawing from a large underground reservoir that is naturally overflowing; the water recovered from these wells might not otherwise be utilized, and large quantities may be withdrawn with the least lowering of the water table and artesian pressures. The effect of pumping from these wells is somewhat similar to that of pumping from a large surface reservoir that is continually overflowing.

Observation wells have been established at strategic locations, to obtain a record of the effects of new groundwater developments on levels and pressures. Measurements of the levels in many of these wells were begun during 1931, and records of the water elevations in more than 150 wells in the valley are available since that time. The levels at which the groundwater stood during a period of about three years before Salt Lake City began its new developments are available; and these records, if continued, will give accurate information as to the relative status of the groundwater reservoir during succeeding years as well as information concerning the effects of the present or future developments.

Fig. 2 is a graph of the water levels in a well located at the edge of the flowing-well area and just above the area of largest groundwater development. The horizontal dash line at El. 4,384.13 represents the top of the well casing; this well flowed during the periods when the water level stood above the dash line. The period of recharge, or of rising water levels, generally begins during April or May of each year. However, the graph shows that practically no groundwater recharge occurred during the spring of 1934 because of the drought with its attendant lack of spring precipitation and runoff.

The general trend of the water level in the well was upward from 1931 until August, 1933, indicating an excess of recharge over discharge, after which the water level continuously fell for a period of more than a year. The increasing rate at which the water level dropped after June, 1934, was probably due to increased withdrawals from existing developments, as practically no newly developed groundwater was withdrawn in the vicinity of the observation well. The new Salt Lake City well just south of the observation well was pumped at a minimum rate of 1.6 m.g.d. between Aug. 4 and 10 only. The new city artesian well, just west of the observation well, was not completed until July 9, and, although it yielded a flow of 1.3 m.g.d., the total groundwater withdrawal in the vicinity was not materially increased, as production of water from this artesian well resulted in a reduction of the flow of adjacent city-owned wells by nearly the same amount as was developed. The cessation of groundwater withdrawals after October, 1934, is indicated by the upward trend of the water level after that time.

To obtain the maximum utilization of the available water supplies in the vicinity of Salt Lake City, it will be necessary to pump enough from the wells so that the artesian reservoir will be at least partly emptied at the beginning of each recharge season, thus providing capacity to store water that under present conditions is wasted. Such extensive withdrawal will unquestionably lower the head in the flowing wells and may cause some of them to stop flowing. This prospective result must be recognized in any comprehensive plan for maximum utilization of the groundwater supplies, and the property rights of the private well owners must be protected by some form of equitable adjustment. (See article on progress in the control of artesian water supplies by O. E. Meinzer, *ENR*, Aug. 9, 1934, p. 167). A forward step in the proper control of the groundwater supplies was taken in a recent enactment by the Utah Legislature, which makes all water the property of the state and places all water within the state under the supervision of the state engineer.

Aberdeen Abandons Wells for a Treated Surface Supply

After 50 years of dependence on highly mineralized deep-well facilities rapidly diminishing in quantity, an impounded surface supply was developed—Storage and diversion dams and a 4-m.g.d. treatment plant built with PWA funds

By W. W. Matthews
With Alvord, Burdick & Howson, Consulting Engineers, Chicago, Ill.

A RECEDING hard-well water supply which, after 50 years' use, caused a water shortage and impeded the growth of Aberdeen, S. D., compelled the city to seek an impounded surface supply with filtration and softening. PWA permitted the financing of two earth dams, a 20-in. cast-iron pipe 7½ miles long, a 4-m.g.d. purification plant and a 500,000-gal. elevated tank. Work was completed this spring in time to impound sufficient water to lift all restrictions as to use this summer. Soap savings are estimated at $25,000, which is more than the fixed charges on the entire investment.

Receding well supply

Prior to 1935, the water supply of Aberdeen, S. D., had been from artesian wells. Several water-bearing sandstone strata underlie the territory adjacent to Aberdeen, but the one which furnishes the largest quantity of water at the greatest pressure is the Dakota sandstone, down about 1,300 ft. Above this sandstone are four other sandstone strata at depths of approximately 850, 950, 1,040 and 1,150 ft. respectively. While the water obtained from the shallower strata has not been plentiful, it is much softer than deep-well supplies, and this has encouraged the development of wells at the shallower depths. Water from the four upper strata has a hardness varying from 3 to 7 gr. per gallon, increasing with depth, while the hardness of the supply at 1,300-ft. depth is 45 gr. per gallon.

Records of water recession maintained by the Chicago, Milwaukee, St. Paul & Pacific Ry. in the soft-water wells over a period of twenty years indicated that a static pressure of 80 lb. per sq.in. at the ground surface in 1910 had receded to a static level of 70 ft. below the surface in 1930, or an average rate of 12.7 ft. per year. At Ellendale, N. D., 40 miles to the north, with similar wells, the static pressure in 1886 was 140 lb., and this had decreased to zero static in 1924, at an average rate of recession of 8.8 ft. per year; pressure in hard-water wells receded at the rate of 20.5 ft. per year in the fifteen-year period 1908 to 1923.

The history of the deep-well supply at Aberdeen is similar to those noted above and to other cities in this locality using underground sources for water supply. During the recent dry years the flow from the wells was inadequate for

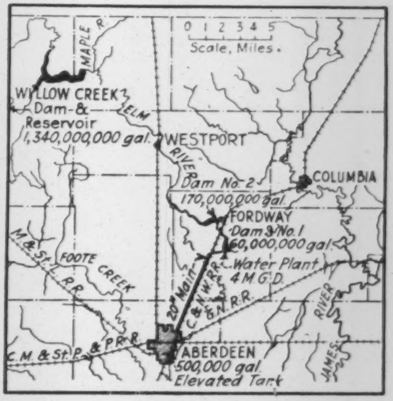


FIG. 1—NEW WATER SUPPLY for Aberdeen, S. D., includes three dams, filter plant, a large elevated tank and 7½ miles of 20-in. cast-iron mains.

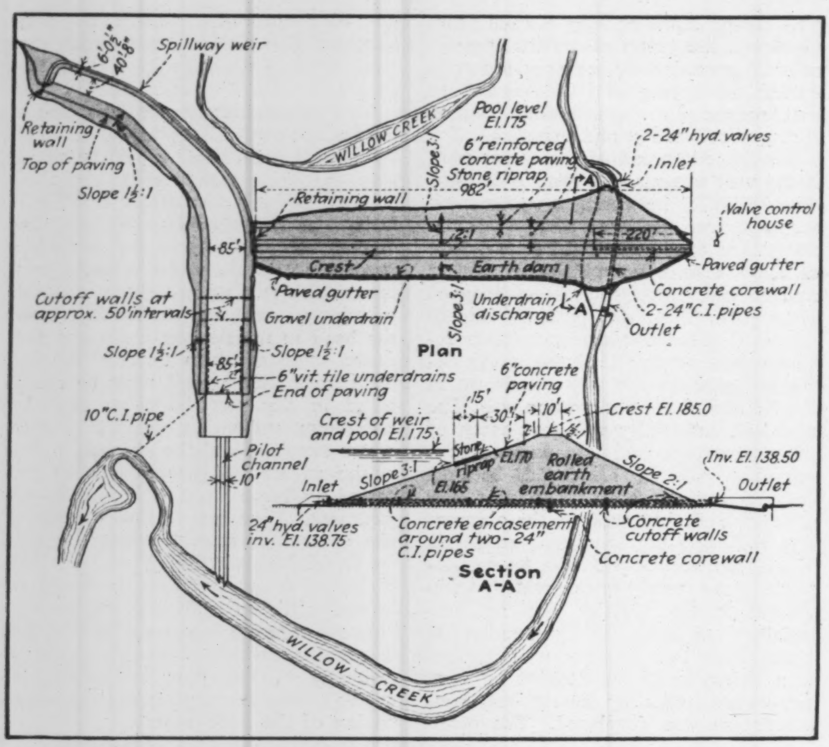

Spillway weir
6'-0½"
40'-8"
Retaining wall
Top of paving
Slope 1½:1
WILLOW CREEK
Pool level El. 175
6" reinforced concrete paving
Stone riprap
Slope 3:1
2-24" hyd. valves
Inlet
982'
Retaining wall
A
Valve control house
85'
2:1
220'
Crest
Earth dam
Paved gutter
Paved gutter
Concrete corewall
Cutoff walls at approx. 50' intervals
Gravel underdrain
Slope 3:1
Underdrain discharge
A
2-24" C.I. pipes
Outlet
Slope 1½:1
Slope 1½:1
Plan
85'
6" vit. tile underdrains
End of paving
6" concrete paving
15'
30'
10'
Crest El. 185.0
10" C.I. pipe
Crest of weir and pool El. 175
Stone riprap
El. 170
Rolled earth embankment
Pilot channel
10'
Slope 3:1
El. 165
Slope 2:1
Inv. El. 138.50
Inlet
Outlet
24" hyd. valves inv. El. 138.75
Concrete encasement around two-24" C.I. pipes
Concrete cutoff walls
Concrete corewall
Section A-A
WILLOW CREEK

FIG. 2—WILLOW CREEK EARTH DAM has curved weir entrance to spillway channel of 2,500-sec.-ft. capacity. Concrete-encased outlet pipes through dam section empty into creek, which is utilized as an open conduit to filtration plant.

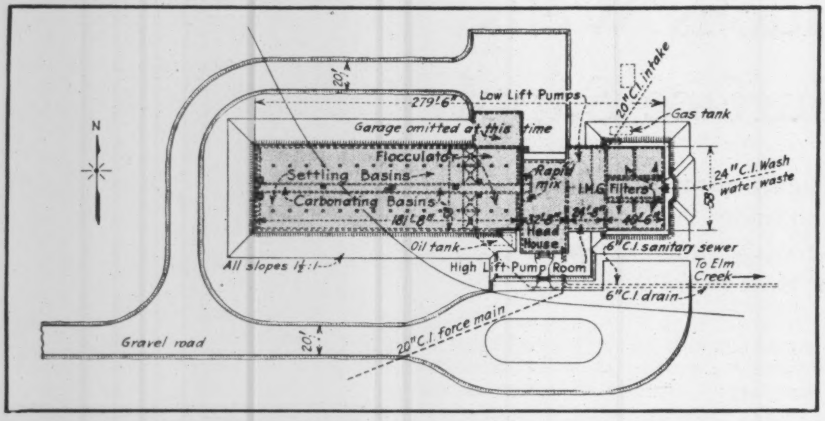

N
20'
279'-6"
Low Lift Pumps
20" C.I. intake
Gas tank
Garage omitted at this time
Flocculator
Settling Basins
Rapid mix
I.M.G.
Filters
24" C.I. Wash water waste
Carbonating Basins
181'-8"
32'-8"
24'-8"
40'-6"
Head House
Oil tank
6" C.I. sanitary sewer
All slopes 1½:1
High Lift Pump Room
To Elm Creek
6" C.I. drain
20" C.I. force main
Gravel road
20'

FIG. 3—ABERDEEN filtration and softening plant on Elm Creek, 7½ miles from town.

days of maximum pumpage and restrictions were necessary, sprinkling of lawns being prohibited entirely for certain periods and later allowed for three hours a day only.

Water shortage and hardness retard city

Aberdeen is an important distributing center in South Dakota, served by four railroads and ranked as the second largest city in the state. In spite of the advantages inherent with the location, Aberdeen has grown more slowly during the past two decades than cities not so well situated, and it was apparent that the lack of growth was in some measure due to the hardness and shortage of water supply.

In 1930 the first steps were taken by the city to develop an increased water supply. Engineers were engaged to make a survey, and they reported that after considering all of the data available on deep and shallow supplies, an impounded surface supply would have to be developed to insure an adequate and satisfactory water.

Impounded sources considered

No streams are available near Aberdeen which have sufficient flow throughout the year to permit surface development without storage. Over a considerable area adjacent to Aberdee the average annual rainfall is betwee 19 and 20 in.; in summer the sma streams usually become dry, and in som years even the larger rivers stop flowing. Four sources for an impounde supply were considered: the Jam River, located 10 miles east of Aberdeen, is the largest river in the region Elm River, 7½ miles from Aberdeen t the northeast and tributary to the Jame River; Willow Creek, which flows int the Elm River about 22 miles north west of Aberdeen; and Foote Creek which could be developed, about 7 miles northwest of the city (Fig. 1).

The James River could not be developed due to a lack of reservoir sites in its drainage area of approximatel 6,000 square miles, including the Elm River drainage basin of 1,000 squar miles. The river has a flat slope an runs through a broad flat valley. A lon dam would have been required, and th reservoir would be shallow with excessive evaporation probabilities and a tendency to favor objectionable growths affecting taste and odor. The distanc from Aberdeen to the James River wa a further disadvantage when mor favorable supplies were available at a shorter distance from the city.

On Elm River, just above the mouth of the Maple River and about 25 miles northwest from Aberdeen, a suitable reservoir site was available above which existed a drainage area of approximately 450 square miles. A reservoir on the Elm River, however, was open to the same objections advanced for the James River site, but ultimately storage on the Elm River may become necessary depending on the growth of the city.

From the topographical standpoint the best reservoir site was found on Willow Creek, 20 miles northwest from Aberdeen where it discharges into the Elm River. The drainage area above this site is 167 square miles. It was estimated that a reservoir with a capacity of 1,340 m.g. here would be sufficient to yield the average daily pumpage for 1950 estimated at 3.9 m.g. per day. Although relatively remote from Aberdeen, a long pipe line was unnecessary as water stored in the Willow Creek Reservoir could be released into Elm River as needed, using the channel as a conduit.

Foote Creek had a suitable reservoir site about 7 miles to the northwest of Aberdeen, but due to a smaller drainage area (100 square miles) a reservoir having a capacity approximately 50 per cent in excess of the reservoir at Willow Creek would be required. This site had another disadvantage in that it could not be developed to take care of the estimated requirements for 1970, and there were many alkali deposits over a considerable area of the watershed.

Because of the greater drainage area, larger available storage, freedom of urban pollution, softer quality of water and lower first and annual costs, Willow

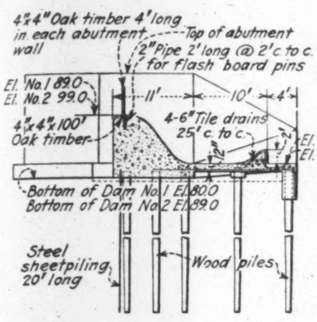

4"x4" Oak timber 4' long in each abutment wall
Top of abutment
2" Pipe 2' long @ 2' c to c. for flash board pins
El. No.1 89.0
El. No.2 99.0
11'
10'
4'
4"x4"x100' Oak timber
4-6" Tile drains 25' c. to c.
12"
2'
El. No.1 82.0
El. No.2 91.0
Bottom of Dam No.1 El. 80.0
Bottom of Dam No.2 El. 89.0
Steel sheetpiling 20' long
Wood piles

FIG. 4—ELM RIVER ogee diversion dams have 4-ft. timber flashboards held up by mild steel rods that bend down when water rises 8 to 10 in. above boards. Weir at end of lower apron creates hydraulic jump.

Creek was recommended for development. The recommendation also included the construction of diversion dams on the Elm River 7½ miles northeast from Aberdeen, to impound 230 m.g., a 4-m.g.d. softening and filter plant at the above location, 7½ miles of 20-in. force main from the water plant to the city, and a 500,000-gal. elevated tank to supplement the low-service storage of 1,250,000 gal. in the city.

Water shortage forces action

After the report had been submitted to the city and published in part by the local newspapers, an educational campaign was started to familiarize the people with the project. In an election called in April, 1931, the proposition failed to carry. On August 29, 1933, after PWA began to function, and during a severe drought and acute water shortage, another election was held at which time a bond issue was authorized by more than 85 per cent of the votes cast. Some of the factors that helped to carry the proposition are as follows: savings possible with a soft-water supply, employment of local labor on the work, the grant from PWA, and last but not least the physical demonstration of the inadequacy of the deep-well supply that had been forecasted earlier but that had been discounted until it actually was experienced.

Bids were received on Oct. 20, 1933, on the Willow Creek Dam and spillway and the 20-in. cast-iron force main extending from the softening plant to the city. On Jan. 5, 1934, bids were received on the remainder of the waterworks structures and equipment. Although the grant and loan were authorized by PWA in October, 1933, funds were not obtained until March, 1934.

Willow Creek Dam construction

The Willow Creek Dam (Fig. 2) is an earth structure 1,000 ft. in length and protected against wave action by a strip of 6-in. reinforced-concrete paving from 5 ft. above to 5 ft. below normal full water line across the entire upstream face of the dam. Riprap of field stone, 15 ft. in width, is placed below the concrete paving.

Before the rolled embankment was started, a concrete corewall was constructed at the north end of the dam, across the creek channel only, for a distance of 220 ft. It is 8 ft. in height. About 5 ft. of the wall is below ground, where it is 18 in. thick, tapering to 12 in. in thickness at the top, 3 ft. above ground. From the south end of this concrete corewall, a trench was excavated 5 ft. deep, 6 ft. wide on the bottom, with side slopes of 1½ to 1, to the south hill, and filled to make a clay corewall.

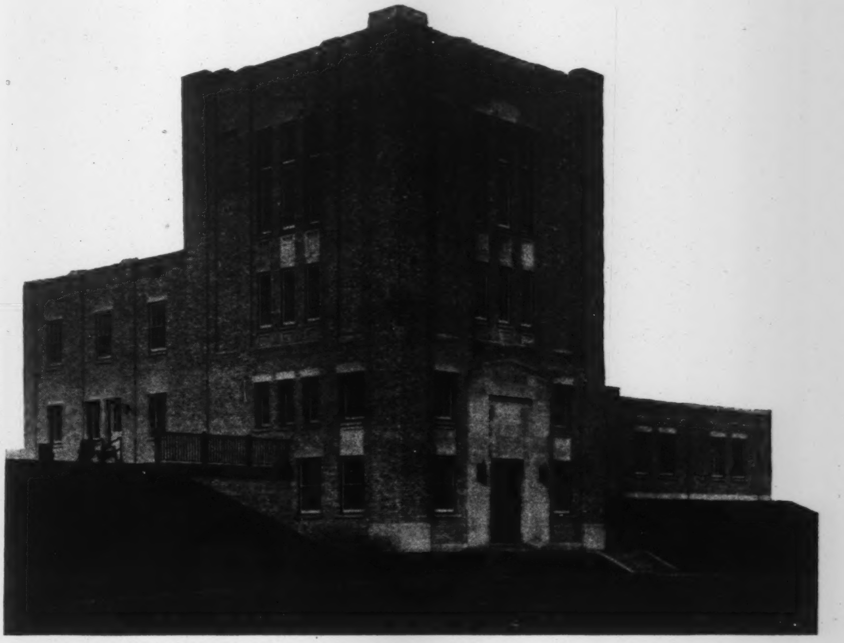


FIG. 5—ENCLOSURE of a washwater tank because of severe winter climate influenced the design of the filter-plant building, which also houses chemical storage bins and pumps.

At the north side of the creek channel, two 24-in. class C cast-iron pipes were laid through the base of the dam. These pipes were encased in concrete, and seven cutoff walls were provided with the concrete encasement. Water will be diverted through these pipes at intervals, so that an adequate supply will always be available behind the dams on the Elm River at the water plant.

Embankment and spillways

Before any material was placed in the dam, the clay base was thoroughly scarified and then sprinkled just ahead of the dumping operations. Dirt was placed from end to end over one-half the base, after which the dumping operations were transferred to the other half of the structure. The material was first dumped in 12-in. layers (loose measurement), then it was bladed and rolled continuously, and enough water was used in sprinkling so that, after rolling, damp spots showed on the surface of the compacted material. Two wells, 1,200 ft. in depth, were required for water supply on the work, as there was no flow in Willow Creek during the construction period. After the embankment had been completed to El. 175, or 10 ft. from the top, dirt work was shut down temporarily, and construction started on the spillway and spillway channel. These structures are located at the south end of the dam on solid ground, the spillway curving around the hill for a distance of 700 ft. above the dam. The concrete-paved channel extends from the spillway crest 350 ft. below the dam, with a dirt channel of the same section continued an additional 100 ft. A pilot channel 10 ft. in bottom width connects the full-sized channel with Willow Creek 700 ft. below the dam. Six-inch tile underdrains were laid under the weir and under the concrete floor at the intersection of the floor and side-slope paving, to prevent the development of upward pressure when the water level in the reservoir was near the crest of the spillway.

The spillway weir has a rounded crest and a capacity of 25,000 sec.-ft., with a head of approximately 6 ft. on the weir. Bottom width of the channel varies from 40 ft. 8 in. at the upper end to 85 ft. at the dam, with a uniform width of 85 ft. continued to the pilot channel.

After the spillway channel and weir were completed, the embankment was built up the final 10 ft. with an additional 6 in. allowed for settlement. Although nine months have elapsed since the completion of the embankment, there has been no apparent shrinkage. The embankment-face pavement is reinforced concrete, 6 in. thick, and has longitudinal cutoff walls along the top and bottom that serve as anchors to the 3-to-1 slope. The reservoir capacity at spillway level (El. 175) is 1,400,000,000 gal.

Elm River diversion dams

Two concrete diversion dams were built on the Elm River, one located 1½ mile downstream from the waterworks plant, 7½ miles northeast of Aberdeen, and the other 3 miles upstream from the lower dam. These dams are of the ogee type (Fig. 4) having a crest 100 ft. in length and wooden flashboards 4 ft. high. The lower dam, No. 1, is 7 ft. in height above the footings, not including the flashboards, and the upper dam is 8 ft. above the top of the footings. The flashboards are held in place by 1¼-in. mild steel rods placed in 2-in. pipe sleeves spaced 2 ft. center to center and embedded in the concrete along the crest of the dam. Storage at top of flashboards is 60 m.g. for Dam 1 and 170 m.g. for Dam 2.

A concrete apron extends 14 ft. downstream from the ogee section, and a discharge weir 2 ft. in height is incorporated in the apron 4 ft. from the lower edge of the apron. This weir creates a hydraulic jump and dissipates the energy of the water before it reaches the creek bed. Water may be diverted through either dam by a 24-in.-square sluice gate. Abutments, dam and apron are on pile foundations. Steel sheeting 20 ft. in length across the front of the dam prevents any seepage under the structure.

The channel of the Elm River is about 100 ft. in width where the dams are located, and these structures are so designed that no appreciable backwater results from the dams during flood periods. When the water overtops the flashboards by 8 or 10 in., the supporting rods bend down and give the full opening above the dam between the abutments. If the flood is of such magnitude that the river channel is entirely filled, it will submerge the dams and abutments without causing any damage to the structures. The loss of head during extreme floods is approximately 6 in.

Softening and filter plant

The 4-m.g. softening and filter plant (Fig. 3), located 7½ miles northeast of Aberdeen on the Elm River, is designed to use lime, alum and soda-ash with carbonation in the softening process. Carbon dioxide is obtained from burning oil in the heating boiler.

The plant includes two rapid mixing basins, two flocculators, two settling basins, lime feeder and slaker, dry-feed machines for soda-ash, alum and activated carbon, CO_2 plant, intake, high- and low-lift pumps, filters, washwater tank, high- and low-lift venturi meters, switchboard equipment, gasoline generator stand-by unit, chlorine and ammonia machines.

A 20-in. cast-iron intake pipe extends from the low-lift pump pit to the pool created by Dam 1, and three low-lift pumps lift the water from the Elm River; two of these have a capacity of 2 m.g.d. and one 4 m.g.d., against a head of 30 ft.

The two concrete settling basins, each 24 ft. 9 in. wide, 152 ft. long and 12 ft. 4 in. in average depth, are provided with straight-line sludge collectors. Flocculators occupy a space 30 ft. in length adjoining the basins on the east, so that the total length of settling basins and flocculators is 182 ft. There are four paddle wheels in each flocculator assembly in each basin.

FIG. 5—RIDING on the line, this ½-m.g. storage tank provides uniform distribution pressure and permits filter-plant shutdown at night.

As normally operated, the water is pumped first to the south rapid mixing basin where lime is applied. At a 4-m.g.d. rate the period of mix is 1 min. The flocculator then provides 30 min. of agitation, after which the water enters the south settling basin for a two-hour detention period. From the effluent trough, where CO_2 gas is applied, the water is conducted downward through a concrete stack until it reaches the rapid mixing basin, where alum is applied. The course of the water through the north basin is similar to that in the south. As it leaves the north basin, it enters the 24-in. influent pipe to the filters. If necessary, CO_2 may be applied to the water in the last pass described above.

The piping and valves are so laid out that the water may be treated in the north basin first, if desired, or the basins may be operated in parallel or singly if necessary. The chemical machines are piped to each rapid mixing basin, and the water may be pre-chlorinated and post-chlorinated. To date, post-chlorination only has been used. Ammonia is used at times, with a small amount of activated carbon applied at the second basin.

The CO_2 plant consists of a scrubber, sulphur remover, motor-driven air compressor and indicating flow gage. Gas is drawn from the flue at the rear of the boiler and, after being washed and cooled in the scrubber, passes through the sulphur remover. It is then pumped to either conduit between the settling basins and applied to the water through a grid of ¾-in. pipes on 8-in. centers. These pipes are perforated with 3/32-in. holes on 15-in. centers turned down.

A 24-in. cast-iron pipe carries the settled water to the four mechanical filters rated at 1 m.g.d. each, but designed to operate at ½ to 1½ m.g. per 24 hours. The underdrain system consists of 2½-in. cast-iron laterals connected to a central header. These pipes are spaced 8 in. on centers and have ⅜-in. perforations on 6-in. centers turned down. Water passes from the filters to a 200,000-gal. clear well located beneath the filters and south half of the pump room. Chlorine is applied to the filtered water in the clear well.

There are three high-lift motor-driven pumps, two 2-m.g.d. at 160-ft. head and one 4-m.g.d. at 200-ft. head. A gasoline-engine generator stand-by unit of 125-kva capacity insures continuous operation during interruption in power service.

The building is brick with Bedford stone trim designed along modernistic lines. A washwater tank is enclosed within the structure because of the severe winter climate. A fully equipped laboratory, office, toilet room and shower bath for the employees are located on the first floor of the building. Chemical-feed machines are placed on the second floor, with hoppers extending to the third floor where the various chemicals are stored. The washwater tank is on the fourth floor in the tower at the front of the building.

Force main

A 20-in. cast-iron force main connects the plant with the distribution system at Aberdeen. Pipe was laid in 18-ft. lengths with leadite and braided hemp jointing, and the minimum depth of cover was 4 ft. The average length of pipe laid per day over the entire job was approximately 1,300 ft., and the best day's work was 1,800 ft.

City pressure was maintained on the line for six months, to tighten up the 2,250 joints before final tests were made. The leakage at 55 lb. per sq.in. was only 404 gal. per 24 hours, or less than 3 gal. per inch-mile per day.

An elevated tank of 500,000-gal. capacity was erected in the southern part of the city, to provide elevated storage on the distribution system. Not only has the use of this tank resulted in a uniform pressure throughout the city, but it has made it possible to carry a higher pressure than was considered safe heretofore with a closed system. The pressure maintained at the present time is 55 lb. per sq.in. subject to the slight variations in the water level in the tank. The tank also permits operating the pumps at full capacity, and the storage available allows the filter plant to be shut down at night.

Water level in the tank is indicated and recorded in the waterworks office in the Municipal Building and indicated at the filter plant, where a high- and low-water alarm gong has been installed.

Completion of the waterworks project in the spring of 1935 occurred just before the end of a prolonged drought. Water was impounded behind the two diversion dams on the Elm River to full capacity of 230 m.g., and an additional 300 m.g. was stored in Willow Creek Reservoir. Up to July, runoff was sufficient to maintain a flow in the Elm River so that it was not necessary to draw on the Willow Creek supply. Lawn sprinkling is now permitted 24 hours per day, and no restrictions of any kind have been required with the new supply. The monthly pumpage for April, May and June, 935, was 28.8 38 and 40 m.g. respectively.

Chemicals now being used are 12 gr. of lime in the first basin, 0.5 gr. of alum and 2. p.p.m. of activated carbon in the second basin. Non-carbonate hardness is negligible at the present time, and soda-ash is not being used. Five pounds of chlorine per million gallons is applied to the filtered water.

Costs and supervision

The Aberdeen waterworks project was financed and built under PWA regulations at a cost of about $570,000, exclusive of real estate, engineering and legal expenses.

W. F. Cochrane was PWA state engineer. Mayor I. N. Douglas was the executive officer for Aberdeen with F. E. Guhin, water and sewer commissioner, in charge of the above departments. Alvord, Burdick & Howson made the preliminary studies and served as engineers throughout the entire work. The writer and R. E. Crawford represented the engineers on the construction of the project.

Improved Management Aids Waterworks Development

Threatened sale of Michigan City, Ind., municipal plant brings new state law, which permits appointed waterworks management separate from city—Result is reduction in city debt, improved credit, modern accounting, new pumps, filters and elevated tank.

By P. C. Gale
Superintendent, Dept. of Waterworks, Michigan City, Ind.

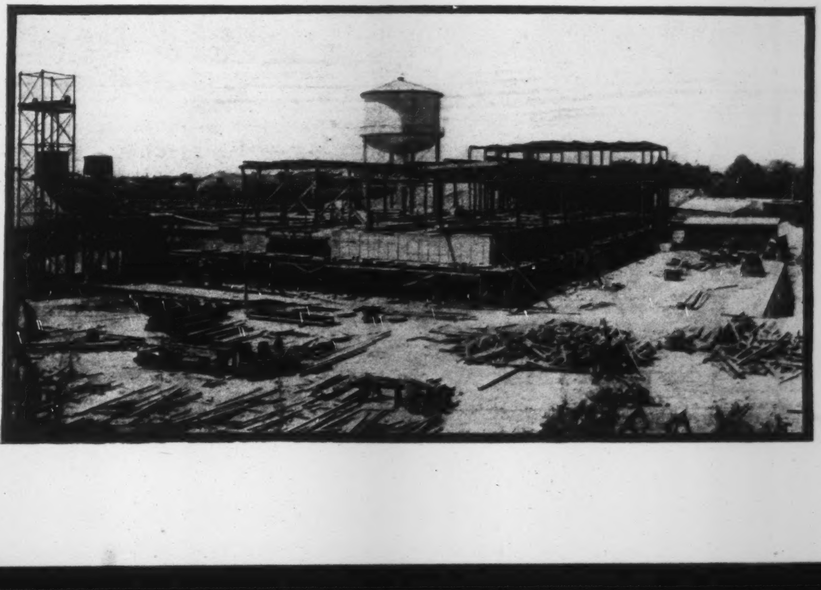
BY PROPER MANAGEMENT on a strictly business basis of the municipally owned waterworks utility of Michigan City, Ind., financial obligations were rapidly reduced, a good credit rating established, and many needed improvements were consummated. Operation procedures were simplified by revamping antiquated records and purchasing methods, rerouting meter districts, and remapping the distribution system. Resulting economies made it possible to provide filtration facilities, additional pumps and elevated storage toward the improvement of the quantity and quality of the water service.

Rescued by state statute

In 1931 the water department was deeply in debt. The accounts receivable were extremely large, and the waterworks were about to be sold to a private utility. Several prominent and public-spirited citizens who were opposed to the sale of the waterworks obtained a temporary injunction and at the same time persuaded the State Assembly to enact a statute providing for a department of waterworks under a board of trustees with independent responsibility for waterworks management. The legislation as originally approved was narrow in title and practically limited in its application to Michigan City, but these defects were remedied in 1933 by a superseding statute that is applicable to all Indiana cities. The success of the statute at Michigan City has encouraged other cities to organize departments of waterworks under it, notably Hammond and Valparaiso. The new law makes possible the formation of a water district (which may extend beyond the city limits), administered by trustees appointed by the city council for a term not to exceed four years. The term of office and the number of trustees, within the limits of 3 to 5, may be established by city ordinance, and the Michigan City council ordained that there should be five trustees with overlapping terms of office of maximum duration, namely four years. It was hoped that this would promote continuity of policy and discourage appointments for political purposes. Waterworks revenue may not be used for general purposes, thus preventing diversion of funds to mask taxation and foster municipal extravagance. These funds are controlled and limited with the understanding that profits must be used for betterments or reduction in water rates.

Most constructive of the features in the new statute is that which protects the superintendent against dismissal. He is appointed by the trustees, but they may not remove him from office except by extending an opportunity for a public hearing. Causes for dismissal are specifically limited and include such items as conviction of a criminal offense, neglect of duty, undue political activity, disobedience of any reasonable order of

FIG. 1—FILTRATION PLANT at Michigan City under construction with washwater tank in background.



the board and absence without leave. If the action of the trustees is unfavorable, the superintendent may carry an appeal to the circuit or superior court of the county in which the city is located. The important element in all this is not the protection of the superintendent as an individual but rather the resulting compulsion on the part of the board of trustees to select a superintendent with extreme care.

Reorganization of department

The trustees selected for the department of waterworks at Michigan City are all business men with no political aspirations. They took office on July 15, 1931, and immediately began, and have since maintained, an extensive program of rehabilitation and improvements.

The first important step was the removal of the department from a single one room in the city hall and court house building to a store building centrally located and easily accessible to the public. The building provides ample office space and permits the location of stock rooms and repair shops in the basement. While this move involved payment of rent, the rent is very reasonable.

Office records were old-fashioned and poorly maintained. Records of property and location maps were deficient and defective. It was necessary to establish an entirely new system of records and office management. Books were changed to ledger sheets; hand billing was changed to machine billing; a system of requisition, purchase orders and stock records was established. Orderly methods were provided for recording and maintaining all data pertinent and helpful to a successful business management. The entire city was rerouted and redistricted for meter readings, and the distribution system was checked in the fiel and mapped.

A petition to revise water rates wit a view to placing them on a more ra tional basis, and also to revise the rule and regulations of the department, wa filed with the Public Service Commi sion of Indiana and approved.

Lax business methods checked

All purchases of materials and equipment are given careful and intelligen analysis. Materials and supplies in general have been purchased after receipt and comparison of quotations but not necessarily at the lowest prices. A vital factor in making purchases is that the department has established an excellent credit rating, thus stimulating dealers to offer their most favorable prices. For three years every cash discount offered has been taken.

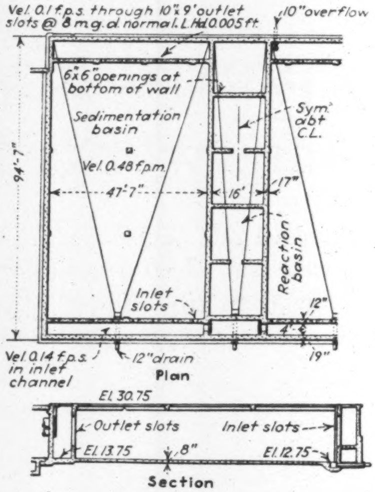

Vel. 0.1 f.p.s. through 10"x 9' outlet slots @ 8 m.g.d. normal. L.Hd 0.005 ft.
10" overflow
6"x 6" openings at bottom of wall
Sedimentation basin
Vel. 0.48 f.p.m.
Sym. abt C.L.
94'-7"
47'-7"
16'
17"
Reaction basin
Inlet slots
12"
4'
19"
Vel. 0.14 f.p.s. in inlet channel
12" drain
Plan
El. 30.75
Outlet slots
Inlet slots
El. 13.75
8"
El. 12.75
Section

FIG. 3—REACTION CHAMBER between two sedimentation basins. Discharge from inlet chambers to basins is through large slots, and collection is by same means, to prevent breaking up of floc.

One of the most useful of the new office records is a card system for recording details relating to service connections. Thus, within a few moments a clerk may determine the exact location of a service connection, the materials used, the date connection was made or changed, the number of the meter and the date of installation, the dates meters were tested and results thereof, complaints, and results of investigations of complaints. Such a record has been especially necessary to offset the bad effects of the loose methods previously employed. In former years it was difficult to refer to the past history of previous claims made by the consumer. Thus consumers were able to avoid paying water bills, or what they regarded as excessive water bills, by merely putting up a good story. To overcome the attitude on the part of certain consumers that they are entitled to

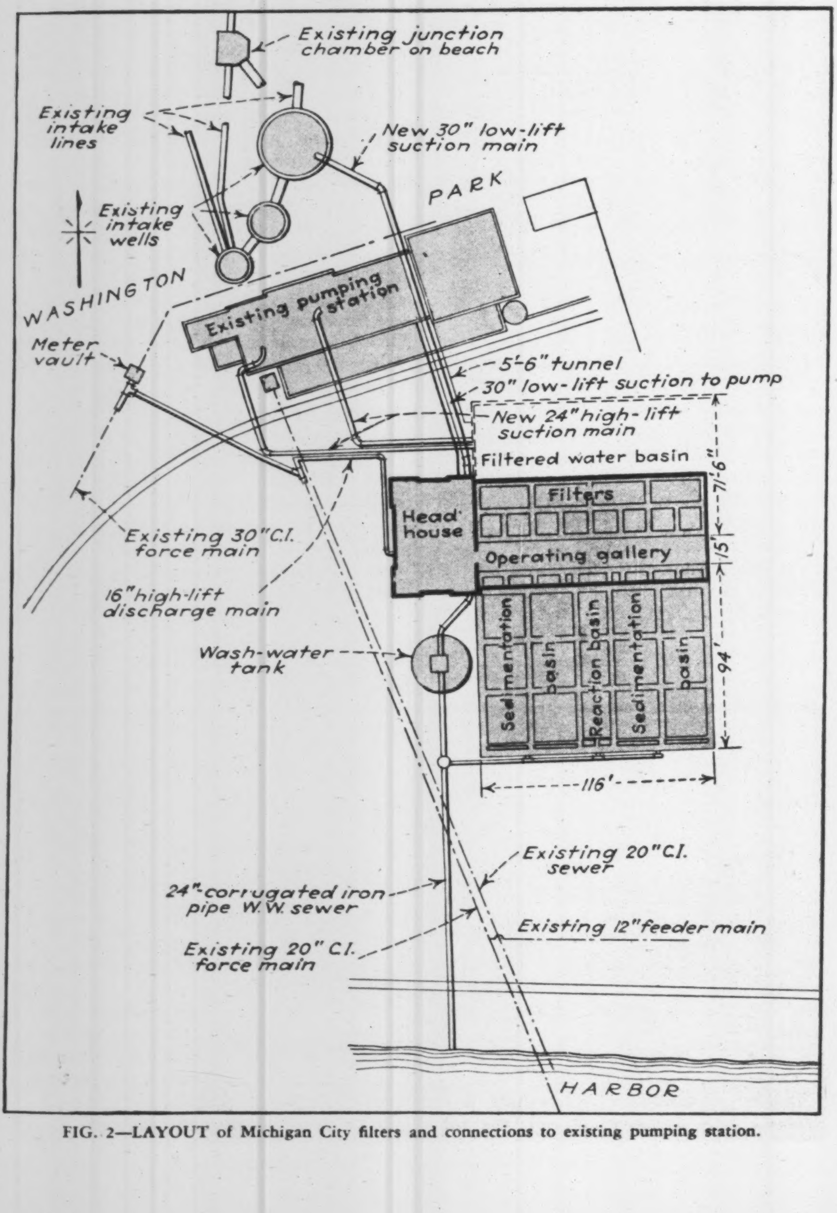

Existing junction chamber on beach
Existing intake lines
New 30" low-lift suction main
PARK
Existing intake wells
WASHINGTON
Existing pumping station
Meter vault
5'-6" tunnel
30" low-lift suction to pump
New 24" high-lift suction main
Filtered water basin
Filters
Head house
Operating gallery
71'-6"
15'
Existing 30" C.I. force main
16" high-lift discharge main
Wash-water tank
Sedimentation basin
Reaction basin
Sedimentation basin
94'
116'
Existing 20" C.I. sewer
24" corrugated iron pipe W.W. sewer
Existing 12" feeder main
Existing 20" C.I. force main
HARBOR

FIG. 2—LAYOUT of Michigan City filters and connections to existing pumping station.

rebates and perquisites on demand, it is necessary to be fortified with accurately recorded facts concerning the history of each connection.

The department has saved much money on repair work by utilizing local machine shops instead of sending to the factory for repair parts on various sorts of equipment, such as pump valves, stoker grates and service-box covers. These local shops now have patterns for various items and can furnish parts on short notice.

An indication of the accomplishments of the new department of waterworks is indicated by the following figures: in 1931 there was outstanding on 5,000 accounts approximately $39,000 in delinquent payments for water service. This has been reduced to slightly over $8,000. An inherited bonded indebtedness of $150,000 has been liquidated at the rate of $22,000 per year plus interest. Other financial accomplishments have been the rapid building up of a surplus, the reduction in cost per thousand gallons pumped and the increase in net income per thousand gallons pumped.

Improvements made with PWA aid

The waterworks, as taken over by the new organization, comprised two intakes, several intake wells (which remove some of the fine sand entering the intakes), a pumping station equipped with steam-operated reciprocating pumps, and a distribution system consisting mostly of cast-iron pipe but still having about 4,000 ft. of old wooden pipe. No storage was available, so that the pumps had to be operated to meet momentary demands. The minimum rate of demand was substantially less than the capacity of any one of the reciprocating pumps, so that in order to obtain smooth operation of the pumps it was necessary to pump in excess of the demand and return some of the pumped water to the suction.

With improved management and resultant economies therefrom, it soon became possible to consider two much-needed improvements: a filter plant to remove sewage pollution, turbidity and fine lake sand from the water; and a substantial elevated storage to improve pumping economy, provide more uniform pressure and maintain an instantly available reserve for fighting fire. To this end the board of trustees, with the aid of Greeley & Hansen as consulting engineers, began negotiations with the RFC in January, 1933. Months were required in negotiating for a loan at 5 per cent. A contract was finally accepted by the RFC in June, 1933, at which time legislation was under active discussion for the creation of PWA, with authorization to make an outright grant of 30 per cent of the cost of construction of the project, and also to offer a lower rate of interest for a loan. The trustees desired to have their application transferred to PWA, assuming that this would be a perfunctory matter, but the rules and requirements of the PWA were such that the loan and grant contract were not completed until May, 1934. Actual construction work was finally started in October, 1934, after further delay caused by local opposition incident to approval of the necessary ordinances.

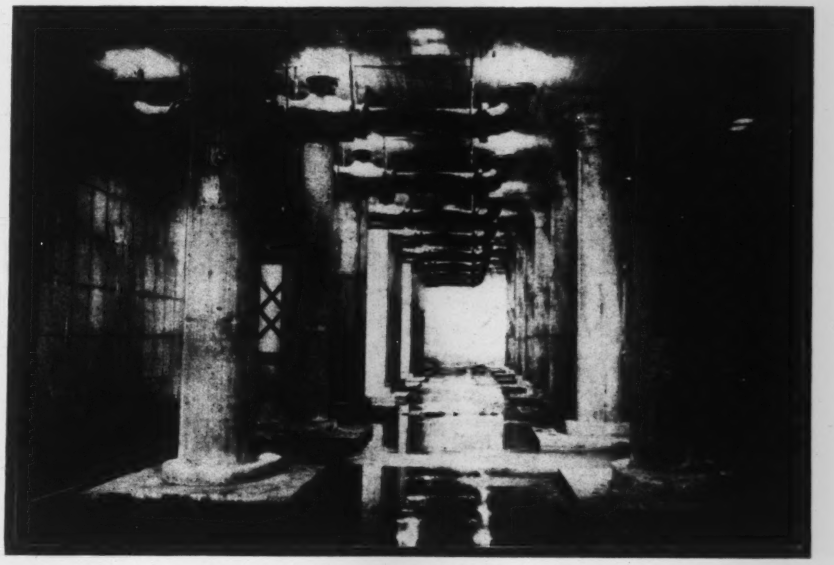


FIG. 4—MAIN FILTER UNDERDRAIN PIPES in clear-water reservoir.

New construction

The filter plant is located adjoining the existing pumping station but independent of it. The plant comprises as main features: a headhouse which also contains pumping equipment; four filters, each with a nominal capacity of 2 m.g.d.; reaction basins with a retention period of about 3 hours; and a 1.5-m.g. filtered water reservoir.

The pumping equipment in the headhouse includes three electrically driven, low-lift, centrifugal pumps with capacities of 3, 5 and 8 m.g.d. respectively. The 5-m.g.d. unit may also be driven by gasoline engine in case of failure of electric power. An electrically driven, 2-m.g.d. pump automatically keeps filled a 100,000-gal. elevated washwater storage tank. The washwater tank may be filled directly from the mains.

The headhouse is a neat but not extravagant building with interior walls faced with terra cotta, which improves appearance and facilitates cleaning. Ample chemical-feed equipment has been installed for the use of alum, ferrous sulphate, lime, soda ash, ammonia, chlorine and activated carbon. Laboratory and office space has been carefully planned, and the equipment is ample for operating control and for limited research.

The filter plant involves nothing particularly new or novel though the following items may be mentioned: special care has been exercised to maintain channels of ample size to avoid breaking up floc and to this end vertical slots 10 in. wide by 9 ft. long have been provided at both the inlet and outlet ends of the sedimentation basins. By blocking up these slots with wood as needed the distribution of water in the basins can be adjusted.

The reaction chamber, equipped with mechanical flocculators, is independent of the sedimentation basins, so that if repairs are required it can be independently taken out of service. The general layout of the filter plant, shown in Fig. 2, is compact, and it has been designed to permit of the independent expansion of sedimentation basins, filters and clear-water reservoir.

Pressure storage is afforded by a 750,000-gal. elevated steel tank built on high ground in the south central portion of the distribution system. The elevation of the tank is such as to provide 45- to 50-lb. pressure throughout the major portion of the distribution system.

The new work also includes replacing some existing wooden pipe with cast-iron pipe. The old pipes are 4 and 6 in. in diameter and are made up of wood staves held together by spirally wound iron bands, in turn covered with thick tar mixed with sawdust. The joints are of the bell-and-spigot type, made tight by a driving fit.

Supervision

The writer, formerly connected with the construction departments of various electrical utilities, is superintendent of the Michigan City department of waterworks. Greeley & Hansen, consulting engineers, prepared plans and are supervising construction of the filtration plant. A. T. Jansen is resident engineer.

Stub Plan Simplifies Water-Consumer Accounting

Routine of water-meter reading, bill preparation and distribution, delinquent procedure and office accounting have been reduced to a minimum at Cincinnati, saving one half former costs

By M. F. Hoffman
Commercial Superintendent, Dept. of Waterworks, Cincinnati, Ohio

THE tremendous growth of the public utilities in the past twenty years has caused accounting procedures to become antiquated in many companies. Although public utility corporations and municipally owned utilities have been in the van in adopting new methods of production and distribution, and by this means have lowered operating costs, very little study has been given to the improvement of accounting technique, particularly consumers' accounting. The need for effecting additional economies in cost of operation has revealed the possibilities in this field, and this article proposes to show the advantages of the stub plan of consumers' accounting.

As is generally known, electric, gas and water consumption is measured by meters. Without weighing the superiority of metered services over flat or assessment rates it is assumed that the advantages of metered services predominate, and the plan to be outlined will be predicated on the use of meters. However, the stub plan of accounting is applicable to both metered services and flat or assessment rates.

Historical — Consumers' accounts were originally maintained in ledgers. As monthly bills were rendered the charges were posted to sheets which maintained a twelve-month record on one side and twelve months on the reverse side. This record for 24 months, was known as the Boston ledger plan. With the advent of billing and addressing machines, and the large number of changes in the accounts during each two-year period, this plan soon became obsolete. It was replaced by the Brooklyn, or register-sheet plan, a one-month record of all accounts.

It was soon found that the preparation of bills and the debit and credit posting to ledgers became cumbersome and militated against the treatment of delinquent accounts to such an extent that a new method was sought.

The Cincinnati & Suburban Bell Telephone Co., associated with the American Telephone and Telegraph Co., had used a modified stub plan of accounting since its inception in 1878. The plan was handicapped originally through lack of control, but this was overcome in 1916. At that time the American Telephone and Telegraph Co. adopted the plan as used in Cincinnati for general use throughout its associated companies. Addressing machines and billing machines were brought into service to prepare the billing. This procedure was so successful that it was later adopted by other utilities, among these Consolidated Gas Co. of Baltimore, through which use it became known among gas and electric companies as the Baltimore plan. However, the plan as set up is fundamentally the same as that used by A.T.&T.—the only changes made have been in the adaptation of mechanical equipment to provide certain statistical data required by public utilities.

The stub plan of accounting

There are two methods that provide the sources of billing for consumers. Flat or assessment rates are established on control cards or sheets, to provide a permanent record for recurring billing periods. Controls are set up for each unit of accounts.

Meter books that show continuous meter readings, whether monthly or quarterly, provide the basis for these billings. This article, as previously noted, deals with metered accounts only.

An addressing system found to be practical is one which provides a metal plate for each consumer. On these plates are stamped, the consumer's or owner's name, address, account number, meter number and service number, together with the size of the meter. The consumer's account numbers should be arranged geographically, to facilitate meter readings. Consumer's meter reading sheets are used which are flexible enough to provide for eighteen or twenty meter readings, thus giving a continuous record of the account. This is essential for checking excess consumption or waste.

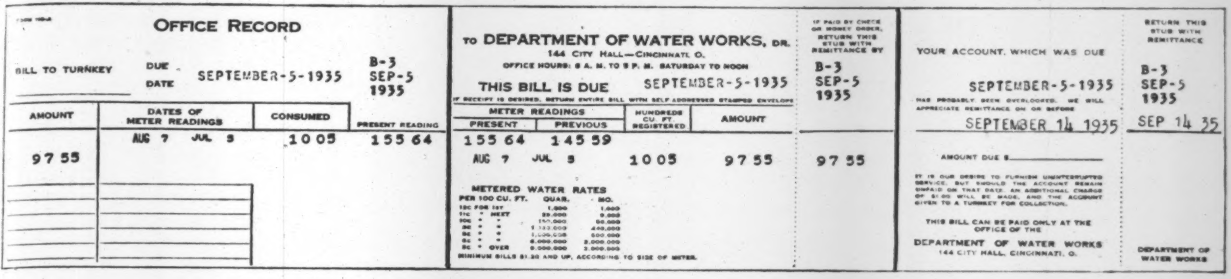
To eliminate peak loads, the cycle or zone method of billing should be used, which provides for a number of billing periods during a monthly or quarterly period in order to maintain a uniform flow of work. The arrangement permits of a balanced organization with a minimum of personnel, and for maximum use of mechanical equipment.

Three-Part Bill—The bill should be a three-part bill, consisting of a consumer's bill, with cashier's stub; a delinquent notice; and an office record. When completed, the three are severed and the bill mailed. One of the advantages of mailing the bill is the immediate delivery of an entire billing unit at one time. Although the cost may be higher than manual delivery by meter readers, it is compensated for through employment of a smaller number of meter readers who are not distracted by other duties. All delinquent notices are retained until the expiration of the original date of payment when the notices on the remaining unpaid accounts are mailed. The office, or accounting, record is maintained in loose-leaf form, and daily payments are credited through the removal of the corresponding office record, matched with the cashier's stub. This gives day-by-day control and provides for immediate action on delinquent accounts.

Meter Books—Bills are addressed prior to the time meter books are taken into the field by the meter readers. They are checked against the meter book, to assure a bill for every meter sheet and a meter sheet for every bill. The bills are then sent into the billing unit, to await the return of the meter books from the field. The books, upon their return, are checked as to accuracy of consumption and amounts to be charged. At this time consumers are informed of excess consumption so that they may take the necessary steps to eliminate waste. The meter books are next sent to the billing unit, where the bills are made up on machines, to show the last and previous meter readings, with the dates, the consumption and the amount. These items are automatically repeated on the delinquent notice and the office record. An audit sheet is prepared, giving the same data as shown on the bill, and these sheets are totaled, to become the basis for the charges that are billed. Journal entries are made before the bills are sent out, and the office records are then given to the accounts clerks for handling.

Payments—As payments are received by the cashiers, stubs are detached and become the record for remittances. The stubs are balanced against the cash total during the day, and a further distribution is made into the various billing units. The stubs are then passed to the accounts clerks, who "pull" the corresponding office record from the files. After these have been removed, they are totaled to balance with the cashier's total. This is proof against crediting the wrong accounts for the payments received. The stubs are then stamped paid, with the date, and filed until the close of the billing period, when they are stored away for reference only. They are not required for public records, as the meter sheet gives a continuous history of the account.

The daily distribution of cash receipts is passed to the general bookkeeper by the head cashier. Allowances and adjustments authorized by the department head are written up in duplicate; the



OFFICE RECORD

BILL TO TURNKEY

DUE DATE SEPTEMBER-5-1935

B-3
SEP-5
1935

AMOUNT	DATES OF METER READINGS	CONSUMED	PRESENT READING
97 55	AUG 7 JUL 5	10 05	155 64

TO DEPARTMENT OF WATER WORKS, DR.
144 CITY HALL—CINCINNATI, O.
OFFICE HOURS: 8 A. M. TO 5 P. M. SATURDAY TO NOON

THIS BILL IS DUE SEPTEMBER-5-1935

IF RECEIPT IS DESIRED, RETURN ENTIRE BILL WITH SELF ADDRESSED STAMPED ENVELOPE

METER READINGS PRESENT	METER READINGS PREVIOUS	HUNDREDS CU. FT. REGISTERED	AMOUNT
155 64	145 59		
AUG 7	JUL 5	10 05	97 55

METERED WATER RATES

MINIMUM BILLS $1.20 AND UP, ACCORDING TO SIZE OF METER.

IF PAID BY CHECK OR MONEY ORDER, RETURN THIS STUB WITH REMITTANCE BY

B-3
SEP-5
1935

97 55

YOUR ACCOUNT, WHICH WAS DUE

SEPTEMBER-5-1935

HAS PROBABLY BEEN OVERLOOKED. WE WILL APPRECIATE REMITTANCE ON OR BEFORE

SEPTEMBER 14 1935

AMOUNT DUE $

IT IS OUR DESIRE TO FURNISH UNINTERRUPTED SERVICE, BUT SHOULD THE ACCOUNT REMAIN UNPAID ON THAT DATE, AN ADDITIONAL CHARGE OF $1.00 WILL BE MADE, AND THE ACCOUNT GIVEN TO A TURNKEY FOR COLLECTION.

THIS BILL CAN BE PAID ONLY AT THE OFFICE OF THE

DEPARTMENT OF WATER WORKS
144 CITY HALL, CINCINNATI, O.

RETURN THIS STUB WITH REMITTANCE

B-3
SEP-5
1935

SEP 14 35

DEPARTMENT OF WATER WORKS

FIG. 1—THREE-PART BILL consists of consumer's bill with cashier's stub, a delinquent notice and an office record. The stenciled address is on back of each part.

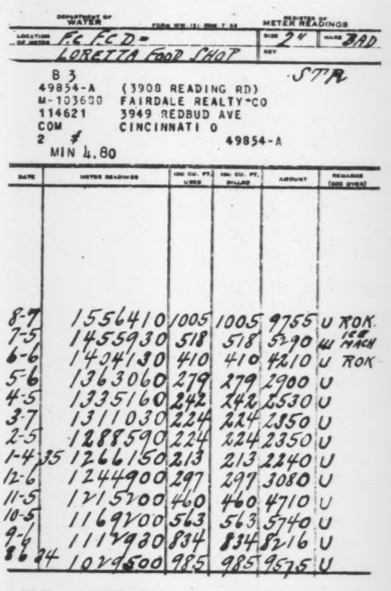
original goes to the general bookkeeper, and the duplicate copy to the accounts clerk for posting to the consumer's account. All journal entries are made up in duplicate, the original being turned over to the bookkeeper and the duplicate remaining with sales sheets comprising the charges. This procedure gives the bookkeeper absolute control of all accounts and prevents any collusion.

Delinquents—At the expiration of the first date of payment the delinquent notices are removed on the unpaid accounts, while the delinquent notices on the paid accounts are destroyed. The second date of payment is stamped in, and the notices are mailed in window envelopes. (It is not permissable under the Post Office Regulations to send a dunning notice on a postcard). At the expiration of the second date of payment, shut-off bills are prepared on the remaining comparatively few accounts. These are typed on fanfold bills, in triplicate, to permit of concerted action. Of the three bills, one copy is retained in the cashier's office, and two revert to the service division, where the head clerk retains one copy and gives the other to the service man for collection or shut-off. Incidentally, the shut-off bill provides for a collection service charge, and this penalty, if it may be so called, has decreased delinquent accounts to a remarkable degree.

The above procedure in the Cincinnati Department of Water Works has been conducive to the smallest number of delinquent accounts on record, and provides such flexibility that partial payments have been handled in a manner to overcome practically every instance of the consumer's inability to pay. In these times of depression this has been a noteworthy factor in maintaining the department's good relations with its consumer public.

A brief summary of the application of this plan in Cincinnati follows:

There are 96,000 consumers, of which number 2,000 are billed every month, as these accounts provide more than half the regular metered-water revenues. Some 33,000 accounts are rendered regularly each month, at intervals of ten-day periods. In other words, 11,000 are rendered every ten days. These are due in ten days, at the end of which time approximately 9,000 accounts will have been paid. Delinquent notices are mailed on the remaining 2,000 unpaid accounts, giving ten days of grace. At the end of that time not more than 300 accounts remain unpaid. Shut-off bills are prepared, and they are given to the service men for action. On their first call 200 to 225 of these accounts are paid, with an additional charge of $1. (In extenuating circumstances, the collection charge may be waived). Twenty-four to forty-eight hours are given to those who have not paid on the first call of the service men. On the second call, two or three days later, collection is made or the water is shut off. In actual practice out of the 300 delinquent accounts in each billing period not more than five or six are shut off, and these shut-offs have usually been found to be due to consumers having moved from the premises served. The serving of a past-due notice on a consumer demands action, and usually it brings them into the office for the arrangement of partial payments. Extensions are granted liberally, and payments usually are made by the date promised.



DEPARTMENT OF WATER
REGISTER OF METER READINGS

LOCATION OF METER F.C F.C D=
LORETTA FOOD SHOP

SIZE 2"
MAKE BAD
KEY

STR

B 3
49854-A (3908 READING RD)
M-103600 FAIRDALE REALTY-CO
114621 3949 REDBUD AVE
COM CINCINNATI O
2 ¢ 49854-A
MIN 4.80

DATE	METER READINGS	100 CU. FT. USED	100 CU. FT. BILLED	AMOUNT	REMARKS (SEE OVER)
8-7	1556410	1005	1005	9755	U ROK
7-5	1455930	518	518	5290	W ICE MACH
6-6	1404130	410	410	4210	U ROK
5-6	1363060	279	279	2900	U
4-5	1335160	242	242	2530	U
3-7	1311030	224	224	2350	U
2-5	1288590	224	224	2350	U
1-4 35	1266150	213	213	2240	U
12-6	1244900	297	297	3080	U
11-5	1215200	460	460	4710	U
10-5	1169200	563	563	5740	U
9-6	1112930	834	834	8216	U
8-6 34	1029500	985	985	9575	U

FIG. 2—SHEET from meter book with entries from bottom up. Notation opposite July 5 refers to note on back of sheet on ice-machine repair. Meter reader's calculations as to consumption and amount of bill are checked, and consumer is notified if charge is excessive. Books then go to billing unit. The name, address, etc., is from the same stencil that the bill carries.

The stub plan provides elasticity through its partial-payment treatment and regular posting of pertinent data concerning the account; it gives at all times a true picture of the particular billing district, and at the close of the billing period only unpaid accounts remain to be dealt with. The billing period is so arranged that by the time the ensuing bills are rendered all accounts have been paid in full.

The quick posting of daily payments to the consumer's record leaves all unpaid files in such convenient and accurate form for reference that any transfers of property can be made with the certain knowledge that the account has been paid at a particular time.

It has been found that the stub plan of consumers' accounting is considerably less in cost than that of the ledger plan. In 1930, with the ledger plan of accounting and monthly billing, the cost of meter reading, billing, collecting and accounting for 88,000 accounts was $255,000.

With the stub plan in effect, 94,000 accounts were handled in 1934; monthly billings were made on large accounts, monthly readings taken on 20,000 of the remaining 92,000 accounts, and quarterly billings issued on the 92,000 accounts, at an operating cost of $125,000. There was also a decrease in the number of delinquents. These savings point to a substantial reduction in water rates. The use of the stub plan further proved that a considerable additional volume can be despatched without any increase in personnel. While this is to some extent due to the operation of machines, much credit is also attributed to increasing efficiency of the personnel.

In line with this improved method of consumers' accounting, additional equipment now available will expedite operations materially. Among these are electrically operated letter-opening machines, check-endorsing machines, automatic coin changers, non-listing computing machines, adding machines, billing machines and addressing machines. A thorough study of the method of operation in any consumers' accounting department of a public utility will reveal a modus operandi which can be developed from the stub plan of accounting to meet local conditions.

Water-Plant Capacity Increased by Modifying Settling Unit

Clarification tank efficiency improved when flow turbulence and floc breakage are reduced by revamped inlet design and lengthened effluent weir

By R. F. Goudey
Sanitary Engineer, Bureau of Waterworks and Supply, Los Angeles, Calif.

THE EXTENT to which carefully controlled flow conditions can affect the settling characteristics of a clarification tank is illustrated by the experience at the Wilmington filtration plant, Los Angeles, where more than four times greater capacity was obtained by making changes, principally in the inlet and outlet design. Shortly after beginning operations in February, 1932, it was found that inadequate settling capacity limited the plant output to 1.5 million gallons per day, although it was designed to treat 5 m.g.d. Subsequent modification of the mechanical clarifier, which constituted the entire settling unit, resulted in the successful treatment of 6 m.g.d. with an occasional daily maximum of 6.75 m.g.d.

The raw water, containing coloring matter varying from 28 to 125 p.p.m., is dosed with 2 grains per gallon of ferric chloride. After a 30-min. period of mixing, the water is settled in a 50x50-ft. tractor-type mechanical clarifier and then filtered in one of six 12x20-ft. rapid sand filters.

The reduction in output below design expectations was traced to: excessive breakage of the ferric hydroxide floc as it passed over weirs or other constrictions; high-velocity currents in the tank, which inhibited sedimentation; and deposition of sludge banks in the corners of the tank where removal was difficult. If sludge was not continuously removed from the bottom of the clarifier, ferric iron was peptized to the ferrous state, and this soluble form passed through the plant into the final effluent. Alpha humic acid, deposited with the coagulum, became the principal food supply of bacteria which reacted with the iron.

Original design

The original installation provided four inlet bays on one side of the clarifier through which the water flowed, over adjustable weirs and at right angles, from an upward sloping influent trough. This arrangement divided the flow satisfactorily, without deposition of sludge, but the weirs broke up the floc. It was also noted that the velocity of the incoming flow was still maintained in the direction of flow in the entering trough until it reached the bottom of the clarifier, where it caused rotation of the entire mass of water in the tank. Considerably more eddying was occasioned by a construction of the inlet bay where it extended into the tank, although a 2-in. wood baffle was installed 18 in. from the clarifier wall to neutralize the forward velocity induced by water descending the 45 deg. slope of the inlet bay.

The outlet for the clarifier, opposite the inlet, consisted of a recessed weir through a 6x12-in. slot below the water line. This was considered inadequate for the overflow, which entered a channel on the outside of the clarifier, operating under a varying head, depending upon the height of water carried on the filter beds. This arrangement not only gave poor flow distribution but caused floc breakage.

The corner-cleaning sludge device created a troublesome condition when it passed in front of the inlet side of the clarifier by causing the settled floc to boil up in different parts of the tank.

Modified design

The remedial measures, details of which are shown in Fig. 1, included the removal of the weir inlets and main-

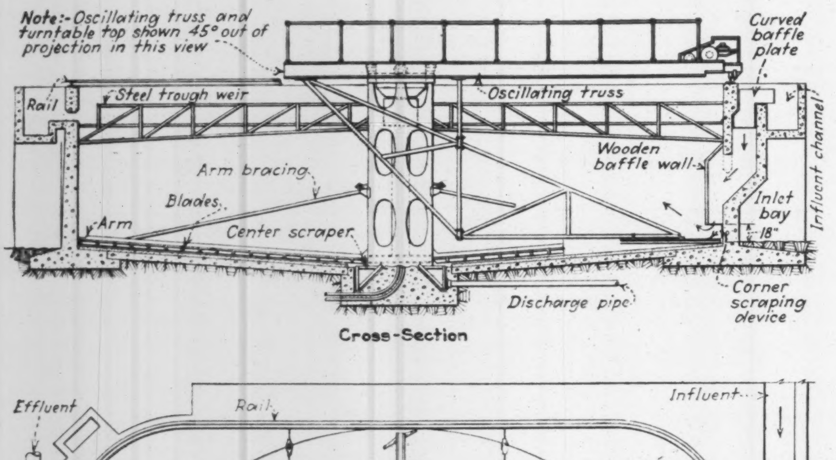

Note:- Oscillating truss and turntable top shown 45° out of projection in this view
Curved baffle plate
Rail
Steel trough weir
Oscillating truss
Wooden baffle wall
Influent channel
Arm bracing
Blades
Inlet bay
18"
Arm
Center scraper
Discharge pipe
Corner scraping device
Cross-Section
Effluent
Rail
Influent
Curved baffle plates
Cable
Steel trough weir
Arm bracing
Oscillating truss
Steel trough weir
Blades
Cable
Plan

FIG. 1—MODIFICATION of the Wilmington clarifier unit included the addition of two steel effluent troughs, a new corner-scraping device and curved baffle plates in the inlet bays.

tenance of an increased head in the clarifier so that there would be no breaking of floc at the influent entrance. Curved baffle plates were installed in the inlet bays with adjustable ends cutting into the flow of the influent channel. This not only provided for equal flow to each inlet bay, but at the same time dissipated the tangential velocity energy of the water by giving it a downward direction of flow; the baffles also constituted individual mixing tanks, which aided in building up the floc. To minimize eddy currents, the constriction of the inlet bay was removed by cutting off the overhanging concrete wall, and the wood baffle was lowered as far as possible without interfering with the clarifier device at the bottom.

The length of weir overflow was increased from 39.5 to 231.5 ft. by installing two steel troughs across the middle third of the tank between the inlet and outlet sides of the clarifier as well as providing additional weir capacity at the outlet side of the tank. These weir troughs were built up of welded steel plates ¼ in. thick, reinforced at the top and bottom with 1¾x3/16-in. angles and stiffened horizontally every 4 ft. with angles of similar dimensions. The weirs skimmed water at the very surface of the tank and were the principal factor in increasing the clarifier capacity from 1.5 to 6 m.g.d. Float-control devices were installed on the inlet to the filters, which backed up the water in the outlet troughs of the clarifier so that only an inch loss of head occurred from the surface of the clarifier to the water in the outlet troughs. This prevented further breakage of floc passing through the clarifier.

To prevent the formation of sludge banks in the corners, a specially constructed scraping device was devised to replace the corner-cleaning mechanism supported by the cowl used in ordinary design. The original scraping shoe was installed on a new support, which consisted of a truss made of 1½-in. and 2-in. pipe hung from the inner end of the oscillating bridge and 12 ft. from the end, so that it would travel in and out of the corners as the clarifier device rotated.

The clarifying rates at the improved Wilmington plant are particularly high and the detention periods low when compared with the performance of settling tanks elsewhere. With a normal flow of 6 m.g.d. the settling rate is 2,600 gal. per square foot per day, and the detention period is 48 min. The clarifier gives about 80 per cent removal of the ferric hydroxide floc, and filter runs are eighteen hours in duration.

Filters and Meters for Chicago Move Toward Reality

Authorized to issue bonds and build structures on lakefront, the city is expected to consummate a long-delayed and much-needed filtration and metering program—Improvements in South District scheduled for first attention

By Arthur E. Gorman

Engineer of Water Purification, Bureau of Engineering, Dept. of Public Works, Chicago, Ill.

● It is almost paradoxical that Chicago, the first of the large Great Lake cities seriously to consider filtration of its water supply and one well informed as to the effectiveness of water purification as a public health measure, should be one of the last to adopt a water-filtration program. Seventy-two years ago Ellis S. Chesbrough, chief engineer of the Board of Public Works, gave consideration to a filtration process as one of three methods of improving the city water supply. From the earliest days in the development of water purification by rapid sand filtration Chicagoans have been prominent in their contribution to the art. Out of the studies conducted at the Chicago experimental filtration plant have come some of the most important advancements in water purification in the last decade. The inauguration of a definite program for filtration of Chicago's water supply is therefore to be considered both a well deserved heritage and a civic accomplishment of real merit.

—Editor.

FILTRATION and conservation, major issues in Chicago's water-supply problem, are definitely slated for early attention through favoring legislative measures passed in July by the Illinois General Assembly. The necessary enabling acts approved at that time permit the sale of $63,000,000 of revenue bonds in the period of 1936 to 1941 and authorize the Chicago Park District to grant permission to the city for the construction of waterworks structures on park property along the lakefront or in Lake Michigan. To clear the way to make the financing of filtration plants possible, an ordinance must now be passed by the city council, requiring metering of all services. Formal action must also be taken by the park district approving lakefront sites for the plants, and permits must be obtained from the War Department and the state of Illinois for the building of structures in navigable waters. Favorable action is anticipated.

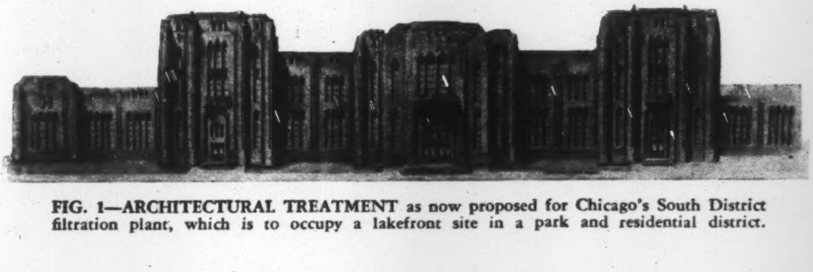


FIG. 1—ARCHITECTURAL TREATMENT as now proposed for Chicago's South District filtration plant, which is to occupy a lakefront site in a park and residential district.

These developments represent the crystallization of a program for metering and filtration advocated repeatedly over a period of several decades, and furthered by special studies during the last eight years during which the water-conservation and financing aspects of the problem were worked out. Other influences which aided materially in expediting recent consideration were as follows:

1. A threatened water shortage in the South Water District.
2. Periods of heavy pollution in the lake waters by sewage and industrial wastes, causing bad tastes and necessitating the use of large quantities of chlorine for public health protection.
3. Realization of the potential hazards to health when the protective feature of diversion of water from Lake Michigan must, under order of the U. S. Supreme Court, be reduced after Dec. 31, 1938, from the 6,500 sec.-ft. allowed at the present time to 1,500 sec.-ft.
4. General knowledge that continuation of water wastage under the present meter ordinance would necessitate a substantial increase in water rates, to pay for extensions and betterments of the water system.
5. Attractiveness of federal grants under the terms of the Work Relief Act of 1935.

South Side District work first

Present plans call for work to be done in the South District of the city water system first, where the situation

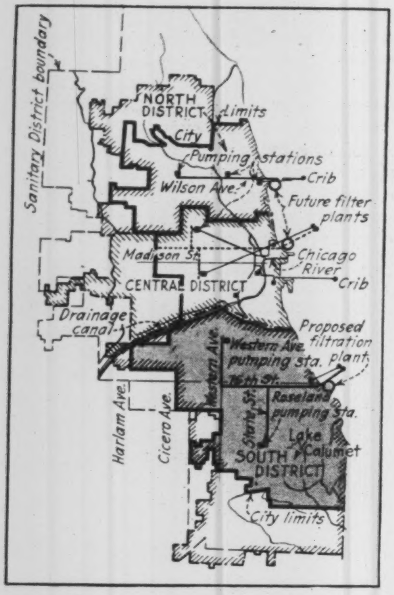


FIG. 2—OF THREE Chicago water districts, the one serving the South Side is planned to be developed first for complete metering and filtration.

regarding both service and quality is most critical. A 384-m.g.d. filtration plant is projected at an estimated cost of approximately $20,000,000, to be liquidated with revenue derived from universal metering and a 10 per cent increase in rates. Application has been made to the PWA for a loan and a grant to start construction, and negotiations are under way to select a site along the lakefront near the present intake crib. The residential character of this location will require a harmonious architectural treatment of the plant buildings.

A decade of difficulties

For ten years or more Chicago has been faced with a potential water shortage, which, in view of declining revenues, has caused the financing of necessary improvements to present one crisis after another. Following the 1923 typhoid epidemic, which gave warning that chlorination as the only line of defense against pollution of the lake water was weakening, serious consideration was given to a program of water conservation through metering, to lay the groundwork for financing the installation of filtration processes. The specific moves forward were the passage by the city council of a universal metering ordinance in 1925, which was subsequently modified, and the construction of an experimental filtration plant for research purposes, which was put into operation in April, 1928.

To date, the metering program has been enforced only among domestic consumers whose water bills amount to $25 per year and over; industrial commercial and other large consumers pay for water under meter rates of 6.8c. per 1,000 gal. net. Under this system the two-flat and residential consumer is permitted to use all the water he wishes at an assessment rate depending on the width of lot and special service requirements. The result has been that the metered consumers, using about one-third of the water pumped, pay about two-thirds of the total income to the water fund, while the average non-metered consumer actually receives water at less than cost. Obviously such a situation was bound to strike a financial snag as more and more of the extensions and betterments were paid for out of borrowed money, and it is surprising that this situation could continue as long as it has without metered consumers raising objections. The answer probably rests with the fact that under the prevailing rates water bills have been relatively low in contrast with those for other utilities.

The program of borrowing to finance betterments instead of paying for them with surplus earnings, which had long been the established practice, started in a major way about 1922 and reached a climax when the General Assembly passed the Waterworks Certificates-of-Indebtedness Act of June 25, 1929, authorizing the issuance of $12,000,000 in water-revenue bonds for the two years 1929 and 1930, and $3,000,000 per year thereafter. Bonds issued under this authority have been spent largely for the new Chicago Ave. tunnel, two new pumping stations, enlargement of existing stations and for feeder mains.

An increase in water rates appeared inevitable in 1930 when the estimated 500-m.g.d. capacity of Chicago's South District tunnel system was reached and money was needed for extension of distribution facilities. At the end of that year the outstanding indebtedness of the water system had climbed to $16,797,100. A large construction program in the north and central section of the city was imminent, and more than $8,000,000 was yet to be spent before the Chicago Ave. tunnel project for the Central Water District could be completed. The Jefferson pumping station for the North Side was under construction, and there was need for enlarging the capacity of the Central Park and Springfield Ave. station. A new central pumping station was projected to replace three old and inefficient ones. Serious water shortages developed in 1931 in the north and northwest sections of the city which were corrected to a considerable extent in 1932 with the completion of new feeder mains. Low pressures in the extreme West Side are still being experienced.

The decline in industrial and commercial water consumption, due to the economic depression, had the effect of postponing the water-shortage crisis on the South Side and to some extent lessened the hazard of lake pollution. But during the period of 1929-1933 a series of events demanded that the problem of water quality receive attention.

The winter and spring of 1929-1930 was one of severe storms on Lake Michigan, and the violence of wave action kept the lake in a continual state of turbulence, causing high turbidities in the city water supply. From about the third week of October until the latter part of April there were only 25 days when the average turbidity of the water was less than 20 p.p.m.; for the first four months of 1930 the turbidity averaged 53 p.p.m., and on many occasions exceeded 100 p.p.m.

A new complication developed in October and November, 1931, when oil-refinery wastes of an objectionable character caused musty-oily tastes in the water supply of the cities along the southwest shore of Lake Michigan north of Whiting, Ind., as far as Waukegan. This pollution affected the water used by over 4,000,000 people and defied the most heroic treatment by activated carbon, the ammonia-chlorine process and other taste-preventive measures. During the last ten days of December, 1933, there occurred a period of excessive chloro-phenol tastes, which lasted about two weeks.

Besides causing extremely objectionable tastes in the water, the pollution of the lake by industrial wastes causes absorption of the chlorine used for safeguarding the water against disease bacteria and thereby lessens the effectiveness of this treatment. The seriousness of this condition is indicated by the great number of periods, when absorption of chlorine prevented the establishment of a residual in the distribution system.

To add to the gravity of the situation, Chicago was visited with a serious outbreak of amœbic dysentery in 1933. Investigations brought out startling facts in regard to the number of carriers of the cysts of the causative organism (E. histolytica) but the public water supply had no part in causing or furthering the epidemic. Although these organisms may survive for months in water and a residual of 25 to 50 p.p.m. of chlorine, depending on contact time, is required to destroy the cysts, it was demonstrated at the experimental filtration plant that effective removal could be accomplished through coagulation and settling followed by filtration of the water.

South District conditions most serious

With the return of normal industrial activities in the Calumet region of Illinois and Indiana the dangers of a water shortage in the South District and intensified lake pollution again created an acute situation. The period needed for the construction of filtration plants will bring the earliest date when they can be put into operation near Jan. 1, 1939, at which time the U. S. Supreme Court order, limiting diversion of water from Lake Michigan by the Sanitary District, becomes effective. This South District, which is so deficient in both water service and quality, is served by the Dunne and 68th St. cribs, the southwest and 68th St. tunnels, and the three pumping stations known as the 68th St., Roseland and Western Ave. stations. A population of 1,200,000 persons is located in this district, which covers an area of 110 square miles, consumes one-third of the water pumped by the entire water system and produces approximately one-third of the revenue derived from the sale of water. Water-consumption characteristics of the section are similar to the average of the combined North and Central Water Districts, and it could easily be made a separate entity in the city water system.

The determining factor in establishing the available capacity of the southwest land tunnel, to meet the maximum hour requirements in the South District, is the hydraulic limitation created by the elevation of the pumps in the South Side pumping stations and not to the available pumping capacity of these stations. The most critical condition is at the Roseland pumping station, which serves a residential, non-metered area and has therefore a serious service demand at the hours of maximum load on the water system. An increase in the hydraulic gradient in this tunnel would mean a greater possible pumpage from these stations.

Original plan abandoned

With the objective in mind of promptly improving the quality of the South Side water and at the same time increasing the capacity of the southwest land tunnel approximately 75 m.g.d., thereby postponing the necessity for metering all consumers, consideration was given in 1932 to a plan for the construction of a settling basin in the lake along the south shore with a direct intake. Such a basin would permit superchlorination and dechlorination of the water for disinfection, and the use of activated carbon or the ammonia-chlorine treatment process for taste and odor control. By chemical treatment for coagulation followed by settling, a reasonably clear water could be delivered to the tunnel systems at all times.

This plan was abandoned because of excessive chemical costs due to the large quantity of water to be treated under a non-metered system. Even with a 13½ hour settling period the estimated average cost of chemicals for treatment, to assure at all times water with a flocculated turbidity not in excess of 2 p.p.m., was $3.36 per m. g.

Assuming a per-capita consumption of 285 gal. per day under a continuation of the present meter ordinance with the settling basin scheme and 170 gal. per day with metering and filtration, it was found that the total annual cost for chemicals under the first plan would be about 80 per cent higher than under the latter. Such high operating costs and the necessity in a few years for a major construction program for supplemental tunnels, pumping stations and feeder mains needed to maintain adequate water service, made this scheme financially impractical.

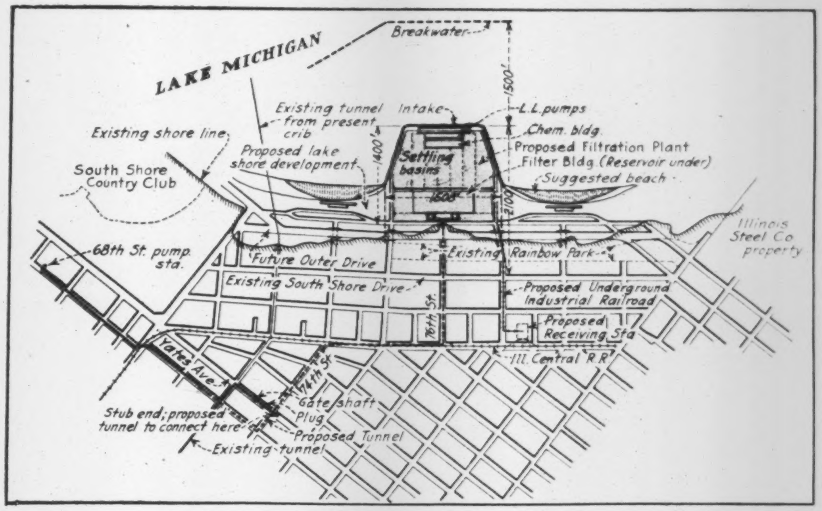


FIG. 3—PLAN FOR FILTRATION PLANT and lakefront development for South District of Chicago water system.

Is 1932 a report submitted to the city engineer, Myron B. Reynolds, by J. B. Eddy, engineer of water pipe extensions, showed that in order to provide water service in the South District under a continuation of the present meter ordinance for the fourteen-year period 1933-1946 inclusive, the following expenditures for betterments and extensions would be required:

Tunnels	$13,089,000
Cribs	750,000
Pumping stations and equipment	4,760,000
Storage	1,313,000
Feeder mains	5,308,100
Small mains	4,879,900
	$31,000,000

Such a program, however, would not insure satisfactory pressures during periods of maximum demand. Financial studies indicated that in order to pay for this construction program out of revenues within a fourteen-year period, there would be required rate increases of 13.7 to 21.0 per cent, depending on the construction schedule adopted. At the end of this time additional betterments would again be necessary unless means were taken to reduce the per-capita consumption of water. Adoption of this program would offer no marked improvement in the quality of the water in the South District, and all the potential future hazards discussed above would still exist. It should be understood that Mr. Eddy, in submitting this report, did not recommend its adoption.

Present plans

In October, 1933, the writer submitted a preliminary report on a combined program for metering and filtering the water supply of the South District over a five-year period, 1934-1938 inclusive, at an estimated construction cost of $21,138,930.

In December, 1933, and again in July, 1934, formal applications were made to PWA for a loan and a grant for this project, but they were not approved. With the passage of the 1935 Federal Emergency Work Relief Act and the announcement of a possible 45 per cent instead of the previous 30 per cent federal grant for eligible public-work projects, the possibility of financing a metering and filtration project for the entire waterworks system of Chicago was studied. This project included the construction of three filtration plants—one for each of the three water districts served by major tunnel systems and the installation of about 300,000 meters. The capacity and estimated cost of the project units were as follows:

Plant	Initial Capacity, M.G.D.	Ult. Cap., M.G.D.	Estimated Costs
North	224	336	$10,500,000
Central	576	720	20,000,000
South	384	640	16,000,000
Total	1,184	1,696	$46,500,000
Meters			11,500,000
Combined total			$58,000,000

Assuming an intensive construction program, it has been estimated that the city would qualify between now and the expiration of the Federal Emergency Work Relief Act—July 1, 1937—for a grant of $13,387,500. With a federal loan for the remainder of funds necessary to finance this project at 4 per cent interest, it has been estimated that this combined metering and filtration project for the entire city would be self-liquidating by, or within, the estimated service period for the initial units. This is based on a 10 per cent increase in water rates, when filtered water is available, universal metering and the establishment of a minimum charge for the smaller domestic accounts.

To date, the city has applied to PWA only for a loan and grant on the South District filtration and metering project.

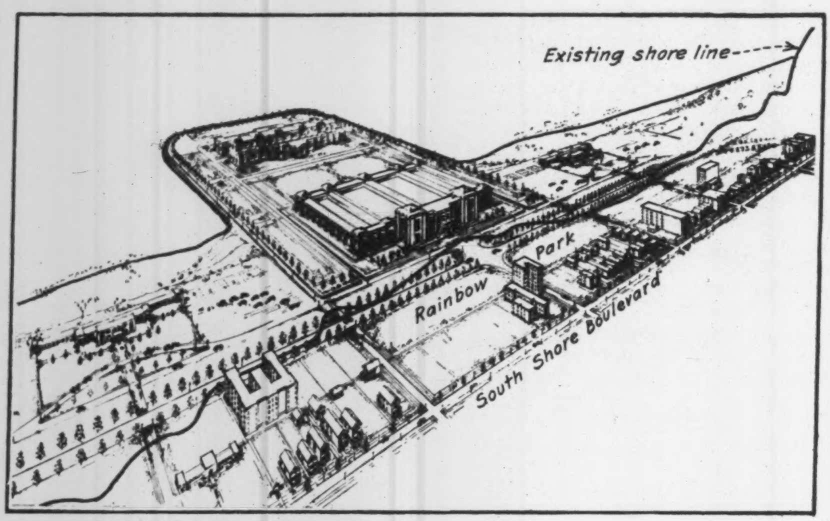


FIG. 4—PROPOSED SOUTH SIDE filtration plant is planned to be coordinated with lakefront and boulevard improvements.

This application, which was filed July 29, is for $21,159,750, of which $8,859,750 is for grant. A loan of $9,300,000 has been requested which, combined with $3,000,000 cash on hand from the sale of 1933 water certificates, will permit financing. It is estimated that the project will be self-liquidating from earned revenue in the South Water District with all bonds retired in 1957, based on 10 per cent increase in rates when filtered water will be available (1939), and the establishment of 60-and 90-c. minimum monthly charges. This would enable the South District to be maintained as a separate unit in the Chicago waterworks system. Construction cost estimates of the project follow:

Lake structures	$1,440,000
Filtration plant	12,430,752
Land structures	2,129,248
Total	$16,000,000
Metering	3,688,358
Grand total	$19,688,350

As a work-relief measure this project has exceptional merit, offering wide diversity of employment in the total of 7,200,000 direct man-hours of work required in a two-year construction period.

The work in connection with the filtration-plant design has been based on the results obtained in operating the experimental filtration plant since 1928. These have indicated that Lake Michigan water, with proper preliminary chemical treatment and settling, can be filtered successfully during the summer at a maximum rate of 4 gal. per square foot per minute of filter area, when the period of operation does not exceed two weeks. During the winter period, because of the possibility of the floc passing through the filters, the experimental work indicates a filtration rate not to exceed 2.5 gal. per square foot.

Applying these limitations with a detailed study of the pumpage characteristics in the South Tunnel zone over a number of years, it has been found that the maximum winter-day demand is the controlling factor in the rate of filtration, and this indicates an average daily rate of 2.3 gal. per square foot per minute for the plant.

Under a metered program the most advantageous size for the first filter plant to serve the South District would be three 128-m.g.d. units, or 384 m.g.d. total capacity. Investigations recommend that the size of filters should be 4 m.g. each, whereby a single unit would consist of 32 filters. The arrangement of filters that appears to be the most practicable for Chicago conditions is four rows of eight filters each, with two pipe galleries per filter unit. Other design features of interest are:

Type of mixing	Mechanical stirrers
Period of mixing	5 min.
Period of flocculation	45 min.
Period of settling	3 hours
Settling basins	Double-decked
Sludge removal	Continuous mechanical scrapers
Sludge disposal	Undecided
Capacity of filtered-water reservoir	36 m.g.
Coagulants	Alum, ferric chloride or chlorinated copperas
Disinfection	Chlorine or ammonia-chlorine
Taste and odor control	Activated carbon

For the South District plant it has been decided to provide an area to be built within a retaining wall in Lake Michigan sufficient for five units, making a total capacity of 640 m.g.d. for the plant. It is estimated that the first three units will be sufficient to meet the requirements of this district until 1960, and that the ultimate capacity will not be reached for 25 years.

A breakwater flanking the plant and about 1,500 ft. from it in the lake is planned for protection from lake storms. A direct intake off the lake end of the plant has been designed to be constructed as an integral part of the retaining wall. The water will enter a covered stilling basin and pass through mechanical screen en route to the low-lift pumping station. The flow elevation on the mixing and settling basins will be +15 Chicago low-water datum. An elevation of +3 in the outlet chamber of the filtered-water reservoir connected to the outlet tunnel will be maintained at all times. Supplemental pumping to this outlet chamber from the clear-water storage reservoir will be necessary at times of maximum demand.

It is estimated that the effect of this additional head on the present land tunnel system will increase the supply capacity to the South Side pumping stations from 500 to 595 m.g.d. This should be sufficient to meet pumping requirements in this district during the financing period of the project, although it may be found desirable to construct a reservoir of 15- to 20-m.g. capacity near the Roseland pumping station, to aid in meeting maximum pumpage requirements for that district.

Many studies have been made with regard to the location of a South Side filtration project, and each indicates the advisability of a lakefront site in spite of possible objections on the part of property owners. The existing tunnel system, pumping station and feeder mains serving this territory are fixed in their location, represent a very large investment and have a potential capacity under a metered system to serve another twenty years or more.

The most satisfactory point at which to locate the filtration plant is along that part of the lakefront near the principal existing tunnel. This would avoid costly tunnel construction needed for an inland treatment plant, and there would be no cost for the site as the property could be acquired from the state for public use. The project could easily be combined with the plans of the former South Park Commission to establish a park on the lakefront between 71st and 79th Streets, by filling in approximately 50 acres of lake area of which the initial plant would occupy 8 acres. It is planned to keep the buildings as low as practicable and to follow an architectural scheme which will harmonize with the lake park setting and give dignity to the South Shore development. Fig. 4 shows the elevation of the proposed filter building as drawn by Fred B. Ayres, architectural engineer of the design division.

The possibilities for filtration of Chicago's water are promising, and it is felt that the proposed projects can be expedited to be of substantial aid in relieving unemployment in Chicago. Mayor Edward F. Kelly has supported the filtration program, which has also had the sponsorship of the commissioner of public works, Oscar E. Hewitt, and the acting city engineer, Loran D. Gayton. Experimental filtration studies were directed by John R. Baylis, physical chemist, and the design and construction estimates were made by Alfred H. Marshall, filtration designing engineer.

Evaluating Pump Efficiency as a Basis for Better Purchase Specifications

By **H. J. Summers**
Assistant City Engineer, Torrance, Calif.

IN WRITING specifications, it is often desirable to place a fixed value on increased efficiency of pumps. However, it is obvious that the more efficient pump is worth more money to the purchaser, and if he would specify how much more money this greater efficiency is worth, this would give the manufacturer an incentive to produce more efficient equipment.

Such a specification would automatically provide for the so-called premium pump or motor, wherein the purchaser pays a premium for a motor that is guaranteed to operate at an efficiency of greater than, say, 92 per cent. Also in such cases, the purchaser could decide after bids are opened whether or not the premium equipment is worth the premium.

Methods of evaluation

There are two ways to arrive at this valuation—namely, by evaluating each point of increased over-all efficiency above a nominal standard, and by evaluating each kilowatt input of power saved for a fixed output. Each of these ways will be analysed herein, and it will be shown that the latter is generally the more equitable.

Certain primary assumptions need to be made:

1. The cost of pump operation is the yearly cost based on the total pump cost during the expected life of the pump, divided by the life.
2. The life of the pump must be definitely assumed according to local experience and practice, beginning when the pump is placed in operation and ending when it is fully depreciated or is replaced due to obsolescence. This sets a certain standard of construction and also fixes the yearly depreciation for accounting purposes.
3. Repair as a factor in yearly pump cost is eliminated because it is not capable of exact analysis.

For any pump the total yearly cost is:

$$T = Cd + Ci + \frac{K\rho}{E} \qquad (1)$$

where T is the total cost per year; C is the first cost; d is the yearly depreciation in per cent; i is the interest rate paid on the money borrowed to purchase the pump; K is the total amount of energy output per year in kw.-hr.; ρ is the cost of energy per kw.-hr.; and E is the over-all pump and motor efficiency.

To compare two pumps under the first method, apply Eq. (1) to each, assigning appropriate subscripts to the terms, and obtain simultaneous equations:

$$\begin{cases} T_2 = C_2(d+i) + \dfrac{K\rho}{E_2} \\ T_1 = C_1(d+i) + \dfrac{K\rho}{E_1} \end{cases}$$

Subtracting:

$$T_2 \rightarrow T_1 = (C_2 - C_1)(d+i) + K\rho\left[\frac{1}{E_2} - \frac{1}{E_1}\right]$$

To have the same yearly cost, $T_2 = T_1$, and

$$C_2 - C_1 = \frac{K\rho}{d+i}\left[\frac{1}{E_1} - \frac{1}{E_2}\right] \qquad (2)$$

Let the difference in over-all efficiency between the two pumps be 1 per cent (.01); then:

$$E_2 = E_1 + .01$$

$$\text{and } C_2 - C_1 = \frac{K\rho}{d+i}\left[\frac{.01}{E_1^2 + .01E_1}\right] \qquad (3)$$

Eq. (3) shows that the difference in first cost between two pumps has a value depending on four constants over which the bidding manufacutrer has no control—i.e., amount of output of the pump (K), cost of power (ρ), yearly depreciation (d), which is set up in the purchaser's books and is arbitrarily predetermined, and interest rate (i). But the value of the difference in first cost is also dependent upon a variable which is the actual efficiency. In other words, one cannot say definitely that an added point of over-all efficiency is worth a fixed number of dollars.

Comparing now, two pumps on the basis of kw. input:

If the required output in kw.-hr. per year is K, and the input is K/E in kw.-hr. per year, the kw. input to the machine is K/En while it is running, where n is the actual number of hours running time in a year. It is necessary to express K/En in terms of first cost, etc.

Therefore, dividing Eq. (1) through by ρn:

$$\frac{T}{\rho n} = \frac{C(d+i)}{\rho n} + \frac{K}{En} \qquad \text{or}$$

$$\frac{K}{En} = \frac{T}{\rho n} - \frac{C}{\rho n}(d+i) \qquad (4)$$

For two pumps:

$$\begin{cases} \dfrac{K}{E_2 n} = \dfrac{T_2}{\rho n} - \dfrac{C_2}{\rho n}(d+i) \\ \dfrac{K}{E_1 n} = \dfrac{T_1}{\rho n} - \dfrac{C_1}{\rho n}(d+i) \end{cases}$$

Subtracting:

$$\frac{K}{n}\left[\frac{1}{E_2} - \frac{1}{E_1}\right] = \frac{1}{\rho n}[T_2 - T_1] - \frac{d+i}{\rho n}[C_2 - C_1].$$

To have the same yearly cost, $T_2 = T_1$ and

$$\frac{K}{E_2 n} - \frac{K}{E_1 n} = \frac{d+i}{\rho n}(C_1 - C_2)$$

Each term on the left of this expression is the kw. input of a pump during running. To evaluate a difference of 1 kw., let the left side equal 1. Then

$$1 = \frac{d+i}{\rho n}(C_1 - C_2) \qquad \text{or}$$

$$C_1 - C_2 = \frac{\rho n}{d+i} \qquad (5)$$

Eq. (5) states that, to have the same total yearly cost for the same output, if one pump saves 1 kw. of power input, it is worth an increased first cost dependent only on four constants, none of which is controlled by the bidders, and the individual efficiency of each pump is eliminated as a consideration.

Two of these four constants, ρ and i, are definitely and permanently fixed, while the other two, d and n, must be either approximated or arbitrarily established. Referring to d, the yearly depreciation, it appears that specifications may be written to secure any reasonably assumed depreciation, by virtue of buying a definite quality of apparatus. Accounting will then definitely fix the yearly depreciation. With respect to the number of hours running time per year, n, the exact duty of a pump is often known in advance, particularly when the running time (or the load factor) is high. In such a case the "increased efficiency premium" is high, but the estimate of n is more exact. Conversely, if n is low and only vaguely known, the error in the "increased efficiency premium" is small in dollars. In the case where n is high and at the same time very roughly approximated, it would probably not be good judgment to write specifications as suggested in this article. Ordinarily, however, the premium could be safely given in the specifications.

This premium for better efficiency could be stated in specifications in some such manner:

> For equal water horsepower output as shown by the test data, the pump which has the least electrical input, measured in kilowatts, will be valued the most, to the extent of \$—— per kilowatt for each kilowatt of power so saved.

The same analysis will apply in the case of pumps driven by any other energy than electrical. For example, a gasoline-driven pump saving G gallons of fuel per hour over another similar pump could be evaluated in terms of gallons per hour saved.

This specification necessitates either careful testing of pumping equipment in the field after installation or certified laboratory tests to be furnished with the equipment. This in itself is good practice for a purchaser. This specification also will permit the use of a penalty clause for any pump that does not conform to the bid as shown by tests.

Specifications just written but not yet published for the city of Torrance, Calif., contain the above provisions regarding kw. input savings being worth additional money. That is, this provision is made use of as an equalizing factor in the bidding and as a penalty if the pumps purchased fail to meet guaranteed performance; no bonus will be paid for better performance than specified.

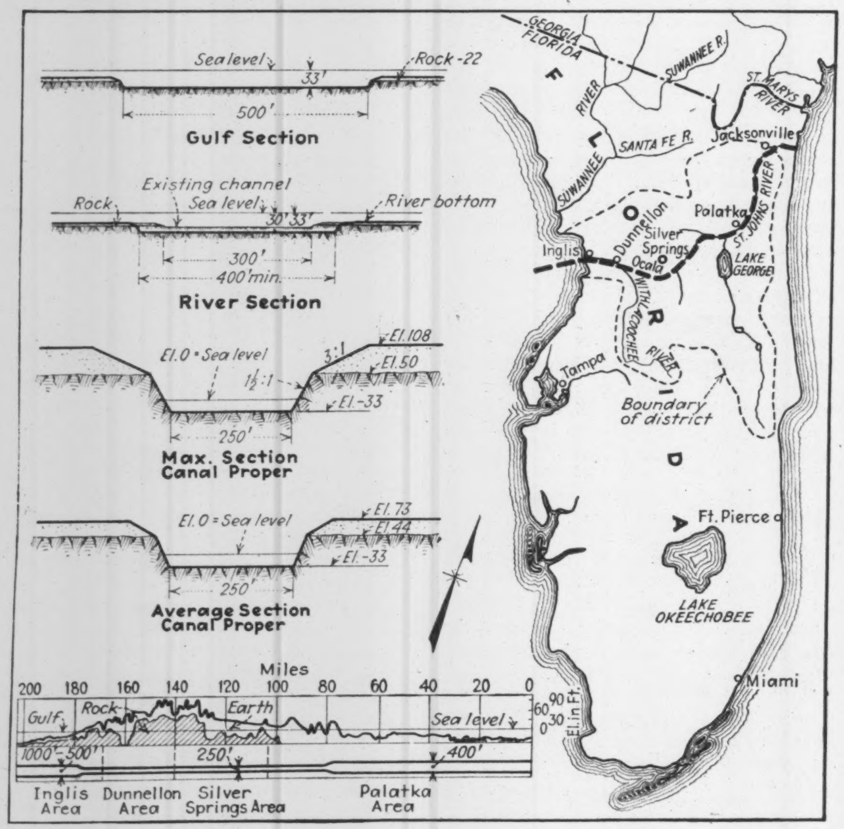
Work on Canal Across Florida to Start Immediately

Route has been chosen and Army Engineers have been pushing preliminary work to point where bids can be called quickly—Question of effect on groundwater supply of state still open

APPROVAL by President Roosevelt on Sept. 3 of an allotment of $5,000,000 from federal relief funds to start construction of a ship canal at sea level across Florida resulted in an immediate move to start the project by the Corps of Engineers, U. S. Army, to whom the construction was assigned by the President. A new engineer district with headquarters at Ocala, Fla., has been set up, and Lieut. Col. Brehon B. Somervell, who is to be in charge, has already left for Florida.

Proposals to finance the project have been before the Administration since the passage of the Relief Act in 1933, and it is understood that it was to be considered by the works allotment board at its first meeting in September. But the President, without waiting for the board to act, authorized the allotment the day after the steamship "Dixie" went on a reef off the tip of Florida.

CONSTRUCTION of a ship canal across Florida, of greater magnitude than the Panama Canal, has been begun under allotment of works-relief funds to the Corps of Engineers.


Sea level
33'
Rock -22
500'
Gulf Section
Existing channel
Rock
Sea level
River bottom
30' 33'
300'
400' min.
River Section
El. 108
El. 0 = Sea level
3:1
El. 50
1½:1
El. -33
250'
Max. Section Canal Proper
El. 73
El. 0 = Sea level
El. 44
El. -33
250'
Average Section Canal Proper
Miles
200 180 160 140 120 100 80 60 40 20 0
Gulf
Rock
Earth
Sea level
90 60 30 0
El. in Ft.
1000'-500'
250'
400'
Inglis Area
Dunnellon Area
Silver Springs Area
Palatka Area
GEORGIA
FLORIDA
SUWANNEE R.
ST. MARYS RIVER
SUWANNEE RIVER
SANTA FE R.
Jacksonville
Palatka
ST. JOHNS RIVER
Dunnellon
Silver Springs
Ocala
Inglis
LAKE GEORGE
WITHLACOOCHEE RIVER
Tampa
Boundary of district
F L O R I D A
Ft. Pierce
LAKE OKEECHOBEE
Miami

The canal has never been approved by Congress, nor has the necessary requisite to a river and harbor project, a report by the Chief of Engineers, been submitted. However, government officials do not anticipate that the project can be stopped on the grounds of unauthorized approval as in the case of Parker Dam. Parker Dam was financed under the National Industrial Recovery Act, which provided that any application of relief funds to river-and-harbor work must be approved specifically by Congress. The works-relief appropriation of 1935, under which the Florida canal is being started, is not subject to this provision and gives the President broad discretion regarding the allocation of funds. A report on the Florida project by the Chief of Engineers is in process of preparation. Presumably the usual routine will be followed and, some time in the future, the project will be officially before Congress for approval.

As shown in the accompanying drawing, the canal will extend along the St. Johns River from its mouth to Palatka, thence by way of the Oklawaha and Withlacoochee rivers to the Gulf of Mexico near Port Inglis. At this point a channel must be cut through an offshore limestone ledge extending 18 miles to deep water. The total length will be 195 miles, of which 95 miles will be artificial waterway with a bottom width of 250 ft., the remainder enlargement of existing streams to a width of 400 ft. and excavation of the Gulf channel, which will be 500 ft. wide at the shore line and 1,000 ft. wide at its mouth. Throughout the canal the minimum depth will be 30 ft., with an overdepth expected to be 2 ft. in the main canal and 3 ft. in the Gulf channel. Side slopes will be ½:1 in. rock; 3:1 in earth.

Necessary appurtenant structures include four spillway dams, where streams flow into the canal, and ten bridges with horizontal clearances of 300 to 500 ft. Half of these, for railway use, will be vertical-lift spans; the others are to be high-level fixed spans with viaduct approaches. All bridges will be built by the government and will have a minimum vertical clearance of 135 ft.

Estimated quantities are given herewith. Excavation will be by power shovel, dragline or dredge, according to conditions. The maximum cut will be approximately 130 ft.

The total cost of the canal is estimated by the army engineers at $146,159,000, and the annual saving in transportation cost to the traffic using the waterway at $7,500.000. Shipping bound to Gulf ports from the North Atlantic Coast and all European ports would be saved an average of one day's time per ship by using the canal and would, in addition, avoid the hurricane belt and dangerous reefs that add to the hazards of the present route.

Larger than Panama Canal

Except in the matter of estimated cost, the Florida canal will be very much larger than the Panama Canal. The excavation involved is more than double. For purposes of comparison, the following figures for the Panama Canal are given: length, deepwater to deepwater 50.5 miles; shore to shore, 40.3 miles; total excavation. 240,000,000 cu.yd.; cost, exclusive of $40,000,000 paid to the French and $10,000,000 paid to Panama, $336,400,000.

Details of how the cost of $146,159,000 for the Florida canal was computed are not available, but it is evident that the army engineers expect that excavation cost on the 570,000,000 cu.yd. to be moved can be kept low. The average will be below 25c. a yard. A large amount can be handled by dredge.

Present work

The $5,000,000 now made available by the President's order will be used for the following purposes: clearing land, $500,000; bridge foundations, $500,000; excavation, $3,500,000. No other work is contemplated at present. and all activities will be concentrated on the central section of the canal, where it crosses the divide. The excavation will consist in taking out the top lift in this area and will be done largely by contract. Other classifications of work will probably be done under force account by the Corps of Engineers. Relief labor will be used almost entirely. It will be housed in temporary camps to be constructed immediately. The present appropriation must be expended before July 1, 1936; what subsequent funds will be forthcoming have not yet been determined.

History of project

Construction of a canal across the Florida peninsula was first proposed about the year 1600 by the Spaniards. Later, under French ownership, actual surveys were made. In 1830 the Board of Internal Improvement of the United States again made surveys, but the size of the undertaking proved too formidable to permit any action. Since that time the idea of a trans-state waterway has been revived at intervals, but the economic obstacle has always blocked construction.

When PWA was first established. the project was re-opened and new reports were submitted, first by PWA engineers (1933) and subsequently (1934) by a special board of army engineers. Neither of these was made public, but it is known that the conclusions reached included the selection of the present route, a recommendation for a sea-level canal as against a lock canal, and a conclusion that a sea-level canal would have only local and inconsequential effect upon the groundwater supply. Plans and estimates for construction were prepared, but the economic factor still seemed insurmountable. To give further study to the latter feature, and to reconcile certain differences in the two reports, the President appointed a board to review the project. This board was composed of Walter J. Douglas, chairman; Col. Warren T. Hannum and Major (now Lt.-Col.) Brehon B. Somervell, of the Corps of Engineers; Clarence McDonough, director of engineering of the PWA; and Frederick H. Fowler, of the PWA board of review.

PRINCIPAL CONSTRUCTION ITEMS

Clearing land, acres	26,000
Excavation in canal prism:	
Earth, dry, cu.yd.	57,758,000
Earth, wet cu.yd.	343,465,000
Rock, dry, cu.yd.	25,000,000
Rock, wet, cu.yd.	143,452,000
Total excavation	569,675,000

Not a self-supporting project

In September, 1934, the board reported unanimously that the proposed canal could not be constructed as a self-liquidating project under PWA regulations since, although the expected revenue would carry operating and maintenance expenses, it could not repay the loan necessary for construction in less than 80 years, even without interest. Furthermore, about 75 per cent of the expected traffic would consist of petroleum and its products, the future volume of which is very uncertain. A toll rate of 8c. per net registered ton would be the maximum possible charge without discouraging use of the waterway and would yield a revenue above operating and maintenance costs amounting to about 1.3 per cent of the money invested.

Proponents of the canal state that its indirect benefits would include work relief, stimulation of commerce, reduced freight and mail rates, lower hurricane hazard, military and naval advantages and the provision of a third route to and from the Panama Canal. No attempt was made by the board to set a monetary value on these factors.

Ship operators apathetic

The board stated that one uncertainty attaches to estimates of revenues from the project because operators of shipping in this country, accustomed to have free use of public waterways, have displayed a singular apathy toward the proposed improvement, particularly if tolls are to be charged. The board added that a substantial part of the proposed canal route is now a free waterway improved by the federal government.

The announcement of the start of work on the canal did not state the conditions under which it is proposed to operate it.

Water-supply hazard

Aside from the low economic value, the principal argument that has been advanced against the construction of a sea-level canal at this location is the fear of its effect upon the fresh-water supply. Under practically the entire state the chief water-bearing formation is a stratum of Ocala limestone, often termed the foundation of the peninsula. Most of the wells and large springs in the state draw from this underground reservoir, which is largely under artesian head. At varying depths beneath the fresh-water stratum the groundwater is brackish from the effect of sea-water infiltration. In the region near Ocala this formation is at or very near the surface, forming a gentle dome that dips away in all directions, but more sharply to the northeast, east and south. Although there are minor intake and recharge areas elsewhere, it is believed that most of the water carried by the porous and heavily channeled limestone enters the formation in the vicinity of Ocala, where the present groundwater level is at El. 40 above sea level.

The western section of the proposed canal traverses this intake area, and the excavated prism will cut through the stratum. What the effect will be on the character of the water, the artesian head under which it flows and the distance over which this effect will extend are still matters of dispute. The problem is complicated by the fact that there is a pronounced "saddle" in groundwater elevation near the canal route which is attributed to the presence of several very large springs, one of which discharges 800 sec.-ft. Advocates of the canal agree with the army reports, which hold that the effect upon groundwater will be local and inconsequential. Opponents of the canal project fear serious saline infiltration, marked lowering of artesian heads, and a consequent decrease in spring and well discharges over a substantial part of the state.

The danger is believed to be particularly acute in the St. Johns River Valley immediately east and southeast of the Ocala intake region. This is a rich truck-growing section where, despite a comparatively low artesian head, water from the limestone stratum is used extensively for irrigation. Here the troublesome factor of salt-water encroachment is already present, and it is felt that a further lowering of the artesian head would seriously upset the delicate balance between fresh and salt water, with disastrous results to the entire region. Once the fresh water is replaced by the heavier salt water, there is little hope of rectifying the condition.

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September 12, 1935

Demoralizing Confusion

AT NO TIME since the federal government relief operation began has there been such demoralizing confusion as that resulting from the mad scramble to meet the Sept. 19 deadline set for the works-relief program. Applications for PWA loans and grants are being thrown out by the hundreds by WPA Administrator Hopkins, because of high cost per man-year. A rumor is widely circulated to the effect that the allowance per man-year has been cut from $1,140 to $700, but this is emphatically denied at the WPA office in Washington. Receipt of PWA applications was closed on Sept. 9, with 782 projects for total grants of only $136,000,000 approved by Hopkins. WPA projects with high costs per man-year also are being discarded in large numbers. The result is all too apparent. City and town officials who have worked hard to get applications through to Washington are disheartened, and their plans for financing a part of the work with their own funds have been set at naught. Industry's prospective share in the $4,000,000,000 works-relief program with the large amount of indirect employment that it promised has dwindled to a negligible amount. The nation is faced with another winter of made work of the leaf-raking class.

The Signs Are Increasing

PARALLELING the indications of revived business enterprise that were noted in this column some weeks ago, the recent RFC sale of municipal bonds deposited for PWA loans is a strong indication of the upward movement in financial tone and business affairs generally. Spirited bidding for the bonds and high prices offered confirm well-informed forecasts made months ago that municipal credit would rise in noteworthy degree. All the facts show a sharp reversion from the ultra-pessimism that three years ago made municipal securities virtually a frozen asset and completely inhibited the continuation of municipal improvements. A market so strong as that now existing open broad opportunity of carrying forward the necessary rehabilitation and extension of community service as fast as good financial housekeeping warrants. It can hardly fail to lead to a growing market for construction and a progressive resumption of activity in a field that has long been suffering seriously from underemployment.

Groundwater Regulation

INCREASED APPRECIATION of the importance of underground water as a source of public water supply is to be had from the experience of Salt Lake City as related in this issue. The drought of 1931, which caused acute shortage in supplies of many cities, emphasized the great value of natural underground reservoirs because these sources were quite unaffected during the dry period. However, like other natural resources, artesian supplies are not inexhaustible, and effective programs of conservation are necessary to promote their use for the greatest good. To assure conservation, proper control and administration are essential. This is a problem by no means peculiar to the western states; many other regions depend on well supplies and are concerned in their conservation—much of the coastal plain along the Atlantic and Gulf coasts, for example. Atlantic City has for some time been alarmed by a lowering of artesian pressure, which is permitting the encroachment of seawater into the fresh-water strata. A recent beginning of administrative control under similar conditions is represented by a law enacted in New York State which required that well drillers on Long Island be licensed after July 1 to operate under the jurisdiction of the State's Water and Power Control Commission. The recent Utah law noted in the article referred to is a more direct attempt to conserve and control groundwater in the general interest. It is important to recognize, however, that regulation requires more than laws, and can succeed only with the development of a more thorough understanding of the intricate physical and legal problems involved.

Abolish Obsolete Speed Laws

IN THESE DAYS of refined highway design and large expenditure to make road transportation more efficient, it would be well if obsolete speed laws were brought up to the level of the engineer's work. Four-lane highways costing upwards of $100,000 per mile and so designed that their curvature, sight distances and signing will permit of safe travel at high speeds are hardly compatible with old-time restrictions to 40-mile speed, or with the still more venerable revenue-collecting systems of local justices. Further, the hazard created by the incompetent, lagging driver is now too well known to maintain the claim that public safety requires narrow speed limits. The fact is that much of our present-day long-distance travel proceeds at *average* speeds far above these antiquated limits. Under such circumstances the retention of statutes that outlaw speeds above 40 or 45 m.p.h. merely breeds disrespect for the law.

In the Right Direction

REPORTS FROM SPOKANE tell of a suggestion made by Commissioner Elwood Mead of the Bureau of Reclamation that should tend strongly toward more businesslike procedure in the conduct of land reclamation. Dr. Mead, according to the reports, advocated government purchase of the entire acreage of irrigable land in the Columbia Basin before constructing the irrigation works. The best result, he said, would be obtained by the government's buying the land, planning and constructing the improvements, and then equitably fixing the terms on which the land would be sold to settlers. If the report is correct, it represents public declaration of a significant new principle in land-reclamation procedure. Facts presented by the special committee which last year reported on federal reclamation policy make it clear that the gravest difficulties of that enterprise arose from the speculative and exploitational elements inseparably connected with the method under which it has been carried on. When the government makes improvements on private land and then endeavors to collect their cost under a loose repayment contract, it unfailingly arrays against itself every self-interest of the local beneficiaries. The tendencies to exploit the government improvement for personal advantage are too powerful to be resisted by all but the rare few. If, on the other hand, desert land is bought by the government—at desert-land value—and the irrigated land later is sold to the settlers, a clean, financially sound arrangement becomes possible. It is greatly to be hoped that the proposal will be pushed forward to definite acceptance as an integrated part of the federal improvement system.

Planning for Water Service

IT HAS BEEN WELL SAID that the highest type of engineering is that which is most farseeing in provision for the future. Measured by this standard the water-supply engineer stands in the front rank of the profession. He is at all times engaged in forecasting many years ahead the community's demand and the capacity of his sources and distribution system, and in planning his works accordingly.

During the depression years this advance planning was severely curtailed. Cities were too poor to make improvements, and at the same time consumption decreased to the point of removing the normal need for extension. Also, operating problems claimed the full attention of depleted waterworks staffs, harassed by shortage of funds, by engineering and legal complications, and by insecure tenure of office. But conditions have changed greatly since the depths of 1932, and the time is at hand when waterworks improvement and planning must be resumed with vigor.

The temporary drop in consumption has disappeared. Domestic as well as industrial use of water is returning to normal. Drought experiences have given sharp warning of the deficiency of many supplies, especially when contrasted with rising quality demands. Wear and tear, unceasingly active during the years of neglected maintenance, have further extended the need for improvement.

Fortunately not all planning and improvement were discontinued. Instructive examples are available of well-planned waterworks modernization and extension under different conditions. The scope of the problems met is typified by the cases reported in this issue, covering the wide range of climatic and service conditions from coast to coast.

In planning for future water service, it would be a grave mistake, however, to think that nothing more is needed than a return to pre-depression plans. Water-service conditions did not remain unaffected during the last six years. Changed population factors, more exacting consumer demands and new consumptive requirements must be taken into account, while, as concerns supplies, the new rainfall records of the dry period call for consideration. All the variable elements of nature's behavior, of community growth and of changed mode of living play a part in making new planning necessary.

In the light of economic shifts, the former growth curves of communities can no longer be accepted, and past estimates of population increase may have to be revised extensively. The rise in quality standards is reflected in Chicago's belated move, expressive of the essential position of filtration today. Storage formerly thought sufficient is now known to be inadequate in extreme dry cycles, and meanwhile the gradual extension of air-cooling and washing presages a heavier draft on supplies.

It is certain that the coming period of water-supply planning will be controlled by these changes. In addition, the relations between the utility and the consumer merit closer attention, since the depression proved that finance and administration are inseparable from engineering planning and that even the soundest project cannot succeed unless backed by solvent, businesslike administration and active public interest. In the new planning, the data and methods of the past may have to be in part discarded; but regardless of whether or not this proves to be the case, it is certain that the next decade will place higher demands on the water-service art than did the past. It is equally certain that an alert and intelligent art will successfully meet these demands.

Precipitate Action

ONCE MORE this country is committed to an undertaking of great magnitude before it has had an opportunity to learn of the character of the work to be done or to appraise its value to the nation as a whole, and even before Congress, which heretofore authorized all national undertakings of any considerable magnitude, has given its approval to the project. This time it is construction of a ship canal at sea level across Florida; a few months ago it was the construction of a great tidal power plant on the coast of Maine.

In the case of the canal this much can be said: it has been the subject of an intensive advance study by the Corps of Engineers, which was not true of the Quoddy power project. But such meager details of the army engineers' and of other recent reports to the government on the Florida canal as have been made public indicate that it is of doubtful economic value. Further, there is serious question as to whether a cut to 30 ft. below sea level across northern Florida will not have a serious effect upon the underground water supply of the state.

Under these circumstances the present haste is difficult to understand. Surely it is not for lack of more necessary projects that could have been undertaken quickly and with equal or better chance of providing useful work! Many separations of highway and railway grades could be built for $5,000,000 in Florida, and the work could have been scattered widely over the state—just as in Maine $10,000,000 would have built many miles of roads to many points that now lack adequate road service.

Possibly the ship canal across Florida should be built, even though it cannot show a return upon the investment; and possibly the nation in the interests of scientific research is justified in spending money to demonstrate the possibilities of developing power from the tides. But neither project should be undertaken precipitately; each should be thoroughly studied to determine when and how best to undertake it.

At Eastport, Maine, work is actually under way on the Quoddy power project before it is known what loads the clay bottom will sustain in the 100-ft.-deep channels that must be dammed; and in Florida the question of interference with the state's water supply assuredly needs more thorough study than it has received before canal construction is undertaken, to say nothing of a decision on whether, in view of the large investment involved, the government should not spend more to obtain a more direct route for the canal. Further, on neither project is money available to complete the undertaking. Congress is vested with that authority, and Congress has not been consulted. Such conditions cannot but result in unnecessary waste.

CURRENT NEWS

Reclamation Projects Receive Added Funds For Continuation

FUNDS for the continuation of three projects being carried out under the U. S. Bureau of Reclamation were approved by President Roosevelt on Sept. 9. The allotments, which total $8,500,000, provide $5,000,000 for the Roza division of the Yakima reclamation project in Yakima, Kittitas and Benton Counties, in Washington; $2,000,000 for the Gila irrigation project near Yuma, Ariz., and $1,500,000 for the Heart Mountain division of the Shoshone project in Wyoming. All of these projects are to be self-liquidating, through repayment contracts negotiated with the water users.

The funds for the Roza division of the Yakima project will be used for the construction of a diversion dam, 99 mi. of main canal, tunnels, siphons and 500 mi. of lateral canals. A hydro-electric plant, with a capacity of 12,000 kw. will also be built. The Reclamation Bureau has spent $2,813,000 on the Roza division, total cost of which will be $14,446,600. The purpose of the work is to provide a gravity water supply to irrigate 11,000 acres which are now being supplied with water pumped from the Sunnyside canal. It will also irrigate 72,000 additional acres in the Yakima Valley.

Gila Valley project

Construction of the first unit of the Gila Valley reclamation project will be started with the recent allotment of $2,000,000. Total cost of this first unit will reach $20,500,000. An area of 150,000 acres of desert land will be irrigated by water diverted from the Colorado River at Imperial Dam, from which water will also be carried into the Imperial Valley, Calif., by the All-American Canal.

The $2,000,000 will be used to construct the diversion structures at Imperial Dam and to carry the main canal as far as the pumping station. Power, from Boulder Dam and Parker Dam, which has been allotted for use in Arizona will be used in pumping water for this project. Where the canal is to go through rock it will be cut large enough to provide for future additions to the project.

Shoshone-Heart Mountain project

The allotment of $1,500,000 will be used to begin construction of the canal system for irrigation of the Heart Mountain division of the Shoshone project in Wyoming. Construction of the main canal through Shoshone Canyon will be undertaken with these funds. The canal system, when completed, will irrigate 41,000 acres. Total cost of this division is to be $6,500,000. All of these projects are being carried out under the newly adopted program of retiring ten acres of land from cultivation for each acre put under cultivation by projects undertaken by the Bureau of Reclamation.

Denver Votes Water Bonds for Change in Fraser River Plans

Denver will turn its new Fraser River water supply into the city mains instead of exchanging it for irrigation rights on the South Platte River, as a result of a favorable vote on a $2,700,000 bond issue on Sept. 10. The proceeds will be combined with a $2,137,725 PWA 45 per cent grant and used to extend the Fraser River canals and conduits some 15 miles from their present proposed terminus at Stony Flats at the head of Dry Creek (see map this issue p. 357) into the city and at the same time to build a filter plant, the Upper Ralston Creek regulation reservoir and the Ashland filtered water reservoir.

An additional $2,700,000 bond issue was also voted to retire the water certificates which were sold to build the Fraser River collecting works on the west slope of the Continental Divide, to line the pioneer bore of the Moffat Tunnel, to improve the channel of South Boulder Creek and to build conduits to Stony Flats. The article on p. 357 of this issue describes this phase of the Fraser River development and the plans as they existed before Tuesday's election enlarged them to include the filter plant, reservoirs and new conduit into the city.

Commission To Investigate Georgia Power Project

President Roosevelt has appointed a commission of three engineers to investigate the feasibility of constructing a $17,500,000 dam on the Savannah River about 17 mi. above Augusta, Ga., as a combined flood control, navigation and power project. The commission consists of Col. Earl Brown, Corps of Engineers; Roger B. McWhorter, chief engineer of the Federal Power Commission; and Sherman W. Woodward of the National Resources Board, a former professor of engineering at Iowa State University and consultant to TVA. The first meeting of the commission will be held on Sept. 12.

A license to construct what was known as the Clark Hill project at this site was voluntarily surrendered Dec. 29, 1932, by the Savannah River Electric Co., a Commonwealth and Southern subsidiary affiliated with the Georgia Power Co. This called for the development of a 90-ft. head. A recent Corps of Engineers' report on the future control of the Savannah River recommends the construction of a dam 18 ft. higher than the originally proposed dam which was to be built at this point under the license.

Amendments Issued for Rules Concerning Highway and Crossing Elimination

UNDER date of Sept. 3 amendments to the rules and regulations for the administration of funds apportioned for the construction of highways and the elimination of hazards at grade crossings under the Emergency Relief Appropriation Act of 1935 have been issued by the Acting Secretary of Agriculture, Rexford G. Tugwell. The principal changes have to do with the employment of labor, penalties for violations of the rules, the basis of approval of projects and alternate plans for grade crossing projects.

The amendments cover the special provisions which were issued on July 12 as well as the rules for the construction of highways and for the elimination of hazards at grade crossings, for all of which separate regulations were set up. Regulations for the two classes of projects differed only in a few respects. Section 6 of the grade crossing rules has been revoked in its entirety. This section provided that all projects were to be measured for approval on a basis of providing the equivalent of a man-year of employment on each project at a total cost to the government of not more than $1,400, or that 40 per cent of the total cost of the project, including the cost of the property, go to persons directly employed on the project. No substitute provisions were offered in place of this section.

Of the special regulations, which apply generally to both types of projects, only sect. 4 has been changed. The first paragraph of this section, which has to do with the employment of labor, stipulated that preference in the employment of labor shall be given (except in executive, administrative, supervisory and highly skilled positions) to persons from the public relief rolls and not less than 90 per cent of all persons working on the contracts shall have been taken from the public relief rolls. This is construed to mean that 90 per cent of the total man-hours of employment under the contracts shall be given to persons taken from the public relief rolls. It is now amended to read as follows:

"Except in executive, administrative, supervisory and highly skilled positions, only persons certified for assignment to work by the U. S. Employment Service shall be employed and preference in the employment of persons so certified by the U. S. Employment Service shall be given, when they are qualified, to those from the public relief rolls. Highly skilled positions are construed to be those listed hereafter under the classification of skilled labor."

The seventh paragraph which said "All labor entitled to preference in employment under the contract to be obtained from lists of available and qualified persons furnished the contractor by the employment agency designated in the contract," has been omitted from the revised rules.

Under the amendments the first paragraph of sect. 12, which was the same for both highways and grade crossing elimination projects, and which read as follows:

"Contracts for all projects under this act shall contain stipulation that preference in employment of labor shall be given (except in executive, administrative, supervisory and highly skilled positions) to persons from the public relief rolls and that at least 90 per cent of all persons working on a contract shall have been taken from such public relief rolls. Only persons certified for assignment to work by the U. S. Employment Service shall be employed, subject to the exceptions mentioned," has now been amended to read the same as the amendment to sect. 4 of the general regulations for both types of projects.

Under the new amendments, sect. 22 of the grade crossing rules was also completely revoked. This section had provided that any state might propose an alternate plan for grade crossing elimination if the state agreed to take from the relief rolls and give employment to its full quota of persons, which was to be determined by dividing the allotment of the state by the allowable expenditure of $1,400 per man-year of employment. No alternative section was announced to take the place of this one.

In both the highway and grade crossing regulations the paragraph under the section having to do with the employment of labor, and which read: "Only one member of a family group may be employed under the contract except as specifically authorized by the secretary," has been omitted.

To the rules for both classes of projects a new section has been added providing penalties for violations. This new amendment states that: "Any contractor who deliberately violates the spirit and the intent of these rules and regulations or the special provisions issued thereunder shall not be eligible to bid upon any further work involving the use of works program highway funds."

Henry W. Lohmann, Vice President of James Stewart & Co., Dies

Henry W. Lohmann, vice president in charge of engineering for James Stewart & Co., New York, died on Sept. 6 at his home in Kew Gardens, Queens, L. I., at the age of 65.

Mr. Lohmann, who was born in St. Louis, began his work with James Stewart & Co. when he was 19 years old. He was first employed as a clerk in the firm's St. Louis office and by continuing his studies after office hours, added to the technical knowledge he had gained during a year or two of engineering training. He was advanced through various positions to the managership of the St. Louis office and in this position had charge of all of the company's work in the Middle West.

In 1913 when James Stewart & Co. was changed from a partnership to a corporation, Mr. Lohmann was elected first vice president. When the company's offices were consolidated in 1916, Mr. Lohmann moved to New York and since then has lived in Kew Gardens. In his position as first vice president he was chief engineering executive of the company. Mr. Lohmann was a strong advocate of safety on engineering and construction projects, and was chairman of the accident prevention committee of the Building Trades Employers Association of New York City for several years following its inception. He was also chairman of the subcommittee on safety appointed by the Merchants Association in 1929.

Haste To Complete Allotments Threatens Loss of Worthwhile PWA Projects

(Washington Correspondence)

AFTER months of confusing delay, the relief works program will be shoved across the deadline Sept. 19. In the rush to complete allotment of the $4,000,000,000 appropriation by that date and reach the goal of 3,500,000 men on payrolls by Nov. 1, PWA's program of public works has been thrown out of the window. Unless the President intervenes to curb Harry Hopkins' veto power, Administrator Ickes will be able to salvage very little from the vast volume of state, city and county projects that have been planned on a 45 per cent grant basis.

Every state and city is assured by Mr. Hopkins that each will get its proper share of the relief works fund, whether particular projects which they have sponsored are approved or not. Although quotas based on the number of employables on relief rolls will be filled, this means, in most cases, that instead of applying federal funds to public works of permanent worth, they will be spent on projects of comparatively little utility.

PWA applications closed

PWA shut down on the receipt of further applications Sept. 9, with more than $1,000,000,000 on its books. On the other hand, reports from various localities stated that WPA engineers are having difficulty in rounding up enough projects to fill their quotas, but Mr. Hopkins had applications for $1,794,000,000 in hand a week ago and claimed $2,500,000,000 by Sept. 12. These are being rushed through the Advisory Committee on Allotments. The large majority of PWA projects never get that far. Most of them were thrown out by the Hopkins' organization because of their high cost per man-year or because the total cost is alleged to be greater than the expenditure necessary to employ available relief labor.

Hopkins has approved 782 PWA projects for total grants of $136,041,661, but has rejected 2,032 for $341,813,626. Both organizations are working night and day, PWA proposing, WPA disposing. President Roosevelt has approved 624 PWA projects for grants totaling $126,738,000, to be supplemented by loans of $76,664,000 from PWA's revolving fund. Loan and grant allotments of $51,231,000 to Los Angeles represent 25 per cent of the total approved to date.

Administrator Ickes will appeal to the President against the scuttling of the public works program. He has striven for months to obtain a roomy berth for public works in the relief works drive by encouraging states and cities to develop projects. The response exceeded his sanguine expectations, but he has been thwarted in his attempt to obtain approval for them. The explanation is plain. The relief works program has been permitted to hang fire so long that now only projects of the simplest character can be gotten under way in time to take 3,500,000 men off relief rolls before snow flies.

Man-year limit not cut

WPA projects show an average cost of $700 per man-year, although the $4,000,000,000 appropriation allows an average of $1,140 for the relief works program as a whole. PWA has been aiming at the latter figure, computed on the 45 per cent grant not on total cost, as the balance either is put up or borrowed by the sponsor of the project. Widespread reports that the allowable cost of PWA projects has been cut from $1,140 to $700 by WPA could not be confirmed in Washington. Feeling between the two organizations is running high. William M. Cotton, project control officer of WPA, asserted that the report was maliciously inspired. He declared that man-hour cost is only one of several elements that determine the eligibility of a project and insisted that there is no specific limitation.

Loan reductions

In an attempt to push more projects through to approval, PWA state directors and engineers are, in some instances, revising proposals by cutting the amount of the grant below 45 per cent. Each 1 per cent of reduction in the grant reduces the man-hour cost borne by the federal government by approximately 2 per cent. Resort to such extreme measures, however, has caused considerable confusion and dismay. Many cities, particularly those which have voted bonds for specific amounts, cannot carry through their projects unless they receive the full amount of the grant. Others likewise will be unable to raise the difference.

Employment

The mowing down of PWA projects will cut off $500,000,000 that local communities would have contributed to the relief works program. Only slam-bang methods can hope to succeed, however, after the lapse of six months in which a carefully developed program might have matured. WPA's program reveals the extremity into which the administration has allowed itself to drift, assuming that no more federal funds will be allotted for direct relief after Nov. 15.

WPA has furnished employment for approximately 250,000, exclusive of 520,000 enrolled in the CCC. Half of PWA's enrollment is in New York City. Federal agencies to which relief works funds have been allotted account for 70,331. WPA has actually submitted applications to the allotment committee for $1,047,000,000, according to the latest available figures. Of this, a total of $593,000,000 has been approved by the President and $320,000,000 has been released by the Department of the Treasury.

Methods protested

Protests against the crack-down on PWA and the summary methods employed at the last minute to force the relief works program through on schedule time are swelling throughout the country. Labor is up in arms as PWA jobs pay prevailing rates and Mr. Hopkins insists that security wage rates on WPA projects will not be raised. The hopes of the heavy industries for large orders for construction materials and equipment have vanished into thin air. Business, in general, has the consolation that $4,000,000,000 will be quickly spent for the necessities of life and consumers' goods. The relief works program is merely a substitute for direct relief.

Ickes goes to Hyde Park

Rapid developments in the relief works program are likely before the week end as Ickes went to Hyde Park on Sept. 11 with Charles West, Under Secretary, and will be joined by Col. Horatio B. Hackett, assistant PWA administrator. The Advisory Committee on Allotments will not be called by Ickes until he has gotten the President's decision on the fate of the PWA. Later reports state that Mr. Hopkins also plans to go to Hyde Park, probably Thursday.

With reference to the rejection of PWA projects by Hopkins, Ickes asserted that there is nothing in President's executive orders which gives anybody the right to veto projects of any other division. All that is contemplated, he said, is that certain information should be annexed by WPA with reference to employment before the applications are forwarded to the allotment committee. On a showing that there is not sufficient relief labor or that the man-year cost is too high, the application may be referred back to sponsors for revision to meet requirements. Average man-year cost of PWA projects which have been rejected by WPA is $958. Asked whether this did not establish their eligibility, Ickes remarked that he's not good at figures but that he did not think he is the only one in the government. When asked whether one reason why so many PWA projects have been thrown out in the short time remaining to get the program under way by Nov. 15, Ickes asserted that PWA can build a school house or dig a sewer as fast as any other organization.

PWA applications number 7,063 for total loans and grants of $1,219,000,000. Ickes is gratified that country has such confidence in PWA, all of which is ammunition in his fight for public works once filed. Applications received prior to Sept. 9 may be revised later, he said.

Municipal engineers protest

Harrison P. Eddy, Jr., president of the American Society of Municipal Engineers, on Sept. 10, upon receipt of news of the wholesale rejection of PWA applications, sent the following telegram to Donald C. Stone, executive director of the society and at present serving as one of the advisers of Harry Hopkins in Washington:

"Fear current widespread rejection PWA applications which come well within announced cost per man-year and all other regulations previously prescribed may cause financial disaster to many of our members and architects who in good faith have done substantial work on such projects in patriotic desire expedite President's program. The situation is particularly distressing in view of the statement that part of grant would be payable at the outset to cover such work. Suggest you personally bring this to attention of Hopkins and Ickes."

American Road Builders To Resume Road Show

A road equipment show will be held by the American Road Builders Association in Cleveland, Ohio, concurrently with the annual convention, Jan. 20-24, 1936. The road show is to be the first since 1933.

Western Society of Engineers Elects L. S. Keith Secretary

To succeed Edgar S. Nethercut as secretary of the Western Society of Engineers effective Sept. 1, Leigh S. Keith, a consulting electrical engineer, has been elected to that position. Graduated in electrical engineering from Massachusetts Institute of Technology in 1900, Mr. Keith next served the New York Telephone Co. as engineer in charge of central office installation and as special assistant to the chief engineer. In 1909 he joined the consulting firm of McMeen and Miller, Chicago, later becoming managing engineer and partner. During the war he was attached to the general staff in Washington. For two years after the war he was associated with J. G. Wray & Co. as special engineer. In 1922 he opened his own office as consultant on public utility and industrial problems. When the Illinois CWA administration organization was set up he joined the staff and remained when the functions were taken over by the Emergency Relief Commission of the State of Illinois.

Mr. Keith was treasurer of the Western Society of Engineers from 1928 to 1932 and vice president for the three succeeding years.

After serving the Western Society of Engineers for eighteen years, Edgar S. Nethercut, secretary and director, has been elected secretary emeritus as of Sept. 1. This action was taken by the Board of Directors after he had announced that he wished to retire to devote his time to travel and historical research in the field of engineering.

Following graduation in civil engineering in 1889 from the University of Wisconsin, he entered the firm of Wade and Purdy as a draftsman. In 1890 he became associated with the Bullock Printing Press Co. and in 1891, he went with Paige Iron Works and the Buda Co., becoming chief engineer, sales manager and director. For 10 years beginning in 1907 he engaged in consulting work.

Virginia and Maryland Cities Flooded by Continued Rain

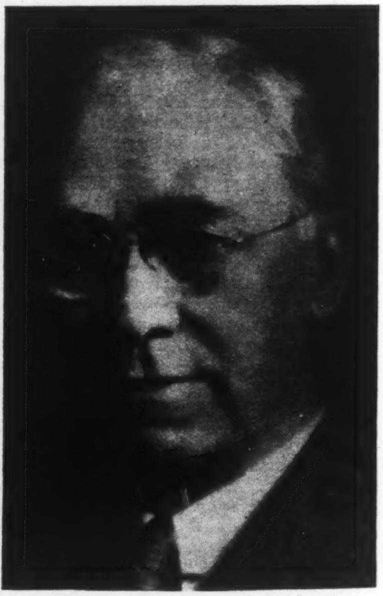
Continued heavy rains in Virginia and Maryland, ending on Sept. 8, sent the James River over its banks flooding Richmond, Va. An earthen dam across the north branch of the Nanticoke River in Maryland collapsed on Sept. 6 as a result of the rain and flooded the town of Federalsburg to a depth of about 10 ft. South Jersey reported extensive crop and property damage and the weather bureau in Philadelphia, Pa., reported a rainfall of 3.83 in. in 24 hours compared with the record of 5.89 in. in August, 1898.

Rain that had lasted for the most part of five days sent the James River in Virginia to a floodcrest of 25.5 ft., which was reached at midnight on Sept. 7. Although the waterfront section of Richmond was inundated, a pumping station located in the lower section of the city is credited with having prevented any larger losses of property. The city gas plant was put out of service for more than 24 hours, but on Sept. 9 had been restored to normal operation. Gamble M. Bowers, director of public works, Richmond, estimated that the damage to sewers and streets was $10,000. Damage to the city's sanitation system was averted by a hastily erected dike of sandbags. Roads and bridges were washed out or damaged by the high water and property damage is estimated to be as high as $1,000,000 in the state.

The town of Federalsburg, Md., was inundated to a depth of from 8 to 10 ft. when an earthen dam across the Marshyhope Creek, the north branch of the Nanticoke River, collapsed on Sept. 6. The river, swollen by the heavy rains, burst through the dam and swept through the town, carrying away a number of houses and doing considerable damage to buildings and highways. Roads leading to Queensboro and Federalsburg were impassable and bridges were out. Two bridges between Trappe and Easton were washed out.

Leigh S. Keith

Edgar S. Nethercut



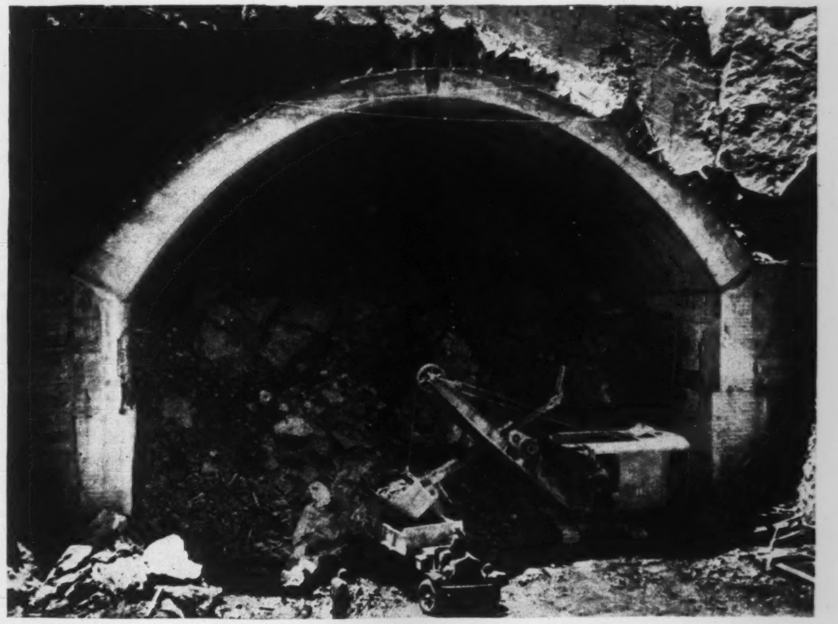
River & Harbor Work Permanent Duty of Army Engineers

THE CORPS OF ENGINEERS of the U. S. Army has, since its inception, been in charge of the improvement of navigable waterways, but the Rivers and Harbors Act of 1935 is the first instance of the adoption of this arrangement as a permanent national policy. In the past such authorization has been given only temporarily by Congressional enactment. The Rivers and Harbors Act, which has recently been signed by President Roosevelt, provides that "hereafter federal investigation and improvements of rivers and harbors and other waterways shall be under the jurisdiction and shall be prosecuted by the War Department under the direction of the Secretary of War and the supervision of the Chief of Engineers."

The Corps of Engineers was first established during the Revolutionary War when General Washington, recognizing a deficiency in military personnel familiar with the construction of fortifications, obtained permission from the Continental Congress to employ one chief engineer and two assistants at salaries of $60 and $20 per month, respectively. The first Chief of Engineers was Richard Gridley of Massachusetts. The Corps was soon expanded in size, the officers being recruited chiefly from French volunteers who had seen service abroad. At the end of the war it was disbanded and was not reestablished until 1794 when President Washington was authorized to employ engineers to design and supervise the fortification of harbors along the coast. The following year Congress authorized the enlistment of a Corps of Artillerists and Engineers, which took over the work and personnel of the civilian unit. The new Corps was stationed at West Point where it started a school that eventually became the U. S. Military Academy.

During the early history of the republic there was a companion organization known as the Corps of Topographical Engineers, started in 1777 when General Washington was authorized to appoint a "geographer and surveyor of the roads to take sketches of the country, the seat of war and to have the procuring, governing and paying of the guides under him." No officers were assigned to this service until the War of 1812. Subsequently the two services were merged and separated several times until they were finally joined together permanently in 1863.

From the earliest period the two organizations have had control over the surveys and plans for seacoast defenses, and have superintended their construction. In addition, they have had almost exclusive control over the improvement of rivers and harbors in the interests of commerce, and their services have been utilized by other departments of the government in the running of boundary lines and the planning and construction of public buildings. Many of the early railroads were projected, built and, in some cases, managed by officers of the Corps. Other accomplishments include completion of the Panama Canal and raising the battleship Maine in Havana harbor. In the field of river and harbor improvements and flood control, it has supervised expenditure of nearly $2,500,000,000.



YERBA BUENA ISLAND TUNNEL

The Yerba Buena Island Tunnel, a part of the San Francisco Bay Bridge project, is being constructed by the rather novel process of placing the lining first and afterward doing the major portion of the excavation. The work was started by driving a 14x14-ft. pilot tunnel at the base of each side wall and an 8x8-ft. tunnel on the crown of the arch. The height of the side tunnels was increased to 40 ft. by stoping down material. From the crown tunnel cross drifts were cut to the side tunnels and then widened until adjacent drifts met. On the inside of this horseshoe-shaped excavation forms were placed for arch and walls. When concrete had been poured and the forms removed, the job was ready for excavating the rock core that had been left in place. This is being done with power shovels, as shown in the picture. A double deck roadway will pass through the tunnel; the length is 540 ft.; inside the lining the width is 58 ft. and the height will be 76 ft.

Business Census To Include A Survey Of Construction

A survey of construction activity will be included in the $7,784,000 census of business which is to be undertaken as a relief project. Enumerators, who will be drawn from the relief rolls, will obtain basic information such as employment and payrolls. An office to direct the new census is to be opened in Philadelphia at once. Some 72,000 white collar workers will be employed on this census of business, the compilation of the list of those eligible for old age pensions and a survey of retail trade.

Power Development Proposal Made to City of Vancouver

An offer to develop power on the Cheakamus River to be sold to the city of Vancouver, B. C., or to assist the city in financing the development of the power and the purchase of the property of the British Columbia Electric Co. now used in serving the city has been made to the city by J. P. Meehan & Co., consulting engineers, Vancouver. The city recently relinquished to the company rights to develop 25,000 hp. on the river to be used for a pulp mill to be established at Squamish, B. C. The Meehan company now proposes that it develop 50,000 hp., half for its use and half to be sold to the city at a price that will give it a fair remuneration, or that the city, using $100,000,000 that it is confident it can find, make the development itself.

SOCIETY CALENDAR

AMERICAN WELDING SOCIETY, fall meeting, Chicago, Ill., September 30 to October 4.

AMERICAN PUBLIC HEALTH ASSOCIATION, annual meeting, Milwaukee, Wis., October 7-10.

NATIONAL SAFETY COUNCIL, annual congress, Louisville, Ky., October 14-18.

PUBLIC WORKS ENGINEERING CONFERENCE, joint meeting of the American Society of Municipal Engineers and International Association of Public Works Officials, Cincinnati, Ohio, October 14-16.

INSTITUTE OF TRAFFIC ENGINEERS, Sixth annual meeting at Louisville, Ky., October 15-16.

AMERICAN SOCIETY OF CIVIL ENGINEERS, fall meeting, Birmingham, Ala., October 16-18.

AMERICAN INSTITUTE OF STEEL CONSTRUCTION, White Sulphur Springs, W. Va., October 16-18.

NATIONAL COUNCIL OF STATE BOARDS OF ENGINEERING EXAMINERS, annual meeting, Columbus, Ohio, October 23-25.

AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS, annual convention, Miami, Fla., December 9-12.

ROCKY MOUNTAIN SECTION, American Water Works Association, annual meeting, Denver, Colo., September 16-18.

NEW ENGLAND WATER WORKS ASSOCIATION, fall convention, Providence, R. I., September 17-20.

NEW ENGLAND AND NEW YORK STATE SEWAGE WORKS ASSOCIATIONS, joint meeting at Schenectady, N. Y., October 4-5.

NORTH DAKOTA WATER AND SEWAGE WORKS CONFERENCE will be held September 30-October 1 at Grand Forks. An operators' water and sewage school is scheduled for the second day. M. D. Hollis, Bismarck, is secretary.

Obituary

Archibald Little, road superintendent of Harford county, Md., and connected with the State Roads Commission since 1911, died in Baltimore on Sept. 2.

Johnston P. Porter, member of the contracting firm of J. P. Porter & Sons, died in St. Catharines, Ont., Aug. 19.

Thomas F. Leonard, 55, engaged in the contracting and building business in Baltimore for many years, died on Sept. 3.

Walter F. Reinheimer, 52, formerly of Warsaw, N. Y., died Aug. 30, in Nutley, N. J. He took his degree in civil engineering at Rutgers University in 1907. He had been associated in later years with the Carlson Co., engineers and building contractors, of Nutley.

Joseph W. Monget, prominent in Louisiana engineering circles, died in Baton Rouge on Sept. 2. He served as assistant state engineer for sixteen years, as city engineer for Baton Rouge for two terms, and for many years was engineer for various levee districts.

William Burleigh, an engineer in the traffic division of the Massachusetts Department of Public Works, died at Natick, Mass., on Sept. 3 at the age of 45. He was graduated from the Massachusetts Institute of Technology in 1911 and spent many years in industrial technology before joining the public works department.

Edward P. Dayton, 46, a civil engineer, who had been engaged for many years in work on construction projects, for the Canada Construction Co., Montreal; New Brunswick department of public works, and Barrett Construction Co., Halifax, died recently in Devon, N. B. He had been on the engineering staff of the Canada Construction Co. for ten years, but at the time of his death he was in the employ of the Irving Oil Co., St. John, N. B.

CONSTRUCTION STATISTICS OF THE WEEK

HEAVY PUBLIC AWARDS swell this week's engineering construction total to $34,977,000, of which $3,966,000 is private construction and $31,011,000 public. Of the public construction, $11,053,000 is federal and $19,958,000 state and municipal. Corresponding figures last year are: total, $20,317,000; private, $4,674,000; public, $15,643,000; federal, $2,842,000; state and municipal, $12,801,000.

The increase over awards reported last week is on a broad base with the largest percentage of gain in waterworks, which total $4,151,000, in sewerage and waste disposal, totalling $3,942,000, and in public buildings, totalling $8,494,000. Streets and roads are up to $6,529,000. Industrial and commercial buildings at $1,791,000 and $1,874,000 respectively are only slightly higher than last week.

The larger contracts for the week include: Irving School, West Roxbury, Boston, Mass., $722,000; post office, Bronx, New York City, $1,032,000; post office superstructure, St. Louis, Mo., $3,636,000; highway awards by Kentucky, $581,000, by Texas, $1,096,000, by Michigan, $805,000 and by Montana, $784,000; reinforcing steel, Metropolitan Aqueduct, Los Angeles, Calif., $3,191,000; garbage destructor plant, 56th St. and 12th Ave., New York City; $1,102,000; Sect. 3, Wards Island Sewage Treatment plant, tunnel, Manhattan and Bronx, grit chamber substructure, New York City, $2,354,000; Island Park dam, Upper Snake River project, Idaho, $479,000; earthwork by U. S. Corps of Engineers, Louisiana, $2,380,000; and swimming pool, bathhouse, by day labor, Thos. Jefferson Park, New York City, $500,000.

New capital for the week totalled $130,987,000 and jumped the total for the year to $1,667,133,000. PWA loans and grants for non-federal work made up $94,792,000 of this week's amount, state and municipal bond sales, $5,113,000, corporate securities $836,000. The balance is due to the 25 per cent of Works Progress Administration allotments and local contributions toward PWA work which is credited to the new capital record.

CONTRACTS

(Thousands of Dollars)

	Weekly Average Sept. 1934	Weekly Average Prev. 4 Weeks	Week Sept. 12 1935
Federal Government	$4,256	$15,049	$11,053
State and municipal	15,021	12,374	19,958
Total public	$19,277	$27,423	$31,011
Total private	4,333	4,563	3,966
Week's total	$23,610	$31,986	$34,977

Cumulative to date:
1934...$979,978,000 1935...$964,540,000

NEW PRODUCTIVE CAPITAL

(Thousands of Dollars)

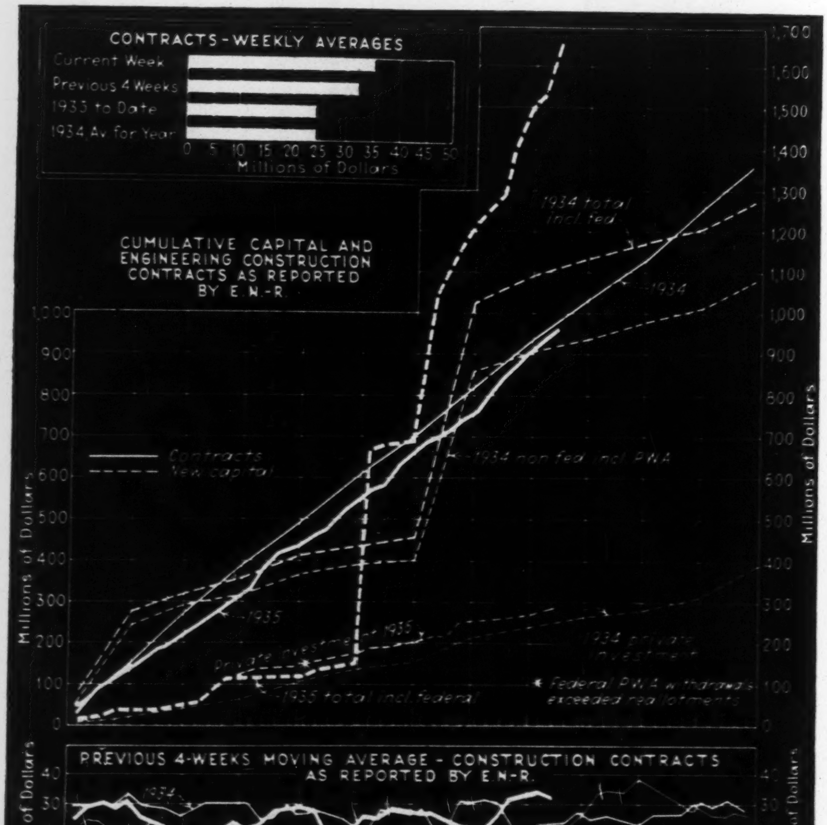
1935	Week Sept. 12	Cumulative
State and municipal	$6,884*	$286,626
PWA allotments, S&M	94,792*	402,829
RFC loans, S&M	.....	36,084
Corporate issues	836	21,989
PWA private	.....	8,629
Local contrib. to WPA	3,443	11,781
Total non-federal	$105,955	$767,938
PWA federal	25,032	899,195
Total new capital	$130,987	$1,667,133

Cumulative to date:
1934..$1,105,876,000 1935..$1,667,133,000

*PWA issues sold for private investment.

Note: These figures include private bonds, and stocks sold for productive purposes; state and municipal bonds for construction; PWA loans and grants to states and municipalities, including the special highway funds; PWA private loans, and allotments for federal construction, deficiency act funds. An arbitrary percentage (25%) of the WPA allotments and local contributions to WPA work is included to allow for the capital additions through the Works Progress Administration division of the new program.

INDEX NUMBER

ENR Cost	1913 = 100	1926 = 100	ENR Volume	1913 = 100	1926 = 100
Sept., 1935	**195.10**	**93.82**	**Aug., 1935**	**140**	**61**
Aug., 1935	195.10	93.82	July, 1935	96	42
Sept., 1934	200.58	96.41	Aug., 1934	94	41
1934 (Av.)	198.10	95.23	1934 (Av.)	114	50
1933 (Av.)	170.18	81.80	1933 (Av.)	102	47
1932 (Av.)	156.97	75.45	1932 (Av.)	127	56